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TECHNOLOGICAL INFORMATION TRANSFER AND DISSEMINATION LEADING TO COMMERCIALIZATION AT THE LEVEL OF THE FIRM

(The Corning Glass Works: "The Corning Ware Case")

by

Gary Sherman Grimes

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B.A., Alfred University, 1964

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CHAPTER I

INTRODUCTION

Technological change has been expounded upon in recent years by scientists, economists and industrialists as a major determinant of the state of the economy and the firm within this larger environment. Numerous studies and statistics abound regarding increases in productivity, income, new industrial ventures and product innovations which serve to establish technological change as a given in today's industrial environment. The firm must therefore effectively understand, respond to and capitalize upon this factor to insure its prosperity and survival.

Technology as applied to the firm is society's pool of knowledge regarding the industrial arts. This consists of the existing bodies of scientific knowledge, principles of production, marketing, management, and organization.[1] Technological change as defined here will comprise two categories; minor or relatively routine technological change associated with recombinations and new applications

[1]Edwin Mansfield, The Economics of Technological Change (New York: W. W. Norton & Company, Inc., 1968), p. 10.

of the existing technological components. This change is associated with few, if any, scientific advances. The second category is major or order of magnitude technological change associated with a major advance of scientific knowledge. This effectively raises the base of technology so the other components may be combined, resulting in superior technological advances. This paper concentrates on this area of technological change. Further, technological change will be considered innovative in nature. That is, this change will be reduced to public practice and brought into widespread use (commercialized).

Technological change results in demand increasing or cost reducing innovations. This paper will orient itself toward changes involving new products or the opening of new markets which are demand increasing. New production methods, organization, or utilization of raw materials which are cost reducing in nature are not less important by implication but merely the subject for another study.

The occurrence of technological innovation requires more than mere existence of information. The firm must communicate the necessary information from external and internal sources to individuals who can apply it, and channel the information to those who can combine it with labor and financial resources for effective utilization. This point cannot be emphasized enough. Technological knowledge existing in the firm's external or internal environs can in itself achieve little economic worth until it marks the way, or is transformed into marketable goods which prove profitable for the firm.

Product innovation does not exist in an independent world. The firm exists as a segment of a larger sphere within which environmental, sociological and competitive factors influence the direction of its technological change. Therefore, the firm must not only consider technology and its underlying sciences, but must, in addition, consider the major factors influencing its technological progress.

This paper will investigate the process of technological innovation. It will explore the conditions a firm creates to facilitate innovation, the components of the process and considerations acting upon the process. Specific attention focuses on technological information transfer and dissemination leading to commercialization at the level of the firm.

The format of this paper initially examines the current literature in an attempt to generate a model of the considerations and process of innovation within the firm. There are many differing views within the field of technological innovation, making it difficult to define a unanimously accepted central position. The model presented is my opinion, in light of current positions, of the most adequate method for transferring technological information to commercialization.

With this model defined the paper proceeds to an examination of the current structure of the Corning Glass Works and its philosophy behind the transfer of technological information.

The paper will then analyze in depth a specific innovative activity, the CORNING WARE case study, to determine the methods Corning at one time utilized in conducting an innovative activity.

The concluding section analyzes the model, Corning's current position and the CORNING WARE case attempting to determine whether Corning follows the considerations defined by the model; how its procedures have changed since the CORNING WARE innovation; and determines the adequacy of Corning's innovative activities. From this process the model may be reinforced or insight gained requiring its revision.

The methods of research used in the paper's formulation were library research, interview, and personal experience. The author's three years of work experience with Corning Glass Works as a shift foreman, in both manufacturing development and automatic glass forming, has been drawn upon to identify the individuals who would contribute most to research interviews and define the significant questions to be resolved during these interviews.

CHAPTER II

THE FIRM

i. Goals and Strategies

The clear establishment of the firm's over-all objectives will identify:

a) In what business the company wants to be.
b) The desirable rate of growth.
c) The over-all direction this growth will take.
d) The method of growth intended; acquisition, internal development; merger.
e) The company's desired image.
f) The basis for organizational framework.
g) Desired market size.
h) Degree of technical flexibility desired.
i) The required rate of return on investment.[1]

The firm's objectives serve to indicate the initial functional components it must possess to assure objective accomplishment. General technological needs derived from the firm's objectives guide the strategies of its individual organization units. This base decides in which scientific and technological areas the firm will concentrate its efforts. Since one firm cannot be pre-eminent in all technological fields due to limited resources it

[1]James Brian Quinn, "Long-Range Planning of Industrial Research," Harvard Business Review (July-August, 1961), pp. 89-90.

must expose itself to some risk and forfeit some opportunities. On the basis of individual strategies determined by the organizational units, specific areas of technology are selected which are deemed to have the highest potential profitability. The company's original corporate plan attempts to minimize serious technological threats to its existence by investigating areas which must be defended at all costs; and outline areas where optimal technological opportunities prevail.

ii. Organizational Environment

To organizationally apply science and technology, which is responsive to customer, competitor and environmental influences, the firm creates special organizational units. In an attempt to facilitate the innovative process the firm can create an organizational environment conducive to coordination of and interaction among these units.

This environment is obtained by establishing an organic organizational structure rather than one mechanistic in nature. The philosophy, embodied hierarchy, and orientation of the organic structure encourages responsiveness to change.[1] By having individuals and organizations responsive to changing conditions and unforeseen requirements the organically structured firm more effectively utilizes its human resources.

Within this framework the firm must promote a common set of values which encourages technological change throughout the organization. The responsiveness to technological change can be accomplished by:

a) Establishing a policy framework and management attitude which encourages flexibility, rewards those responsible for successful changes and promotes cooperation among organizational units.

b) Control the organization toward long-term goals so that its members are not overwhelmed by short-sighted, quick profit opportunities.[2]

iii. Corporate Planning

The firm's corporate planning function is a major factor in coordinating information from Research, Development, Marketing, and Finance to provide the basis for an updated evaluation of the current and future technological needs of the organization. From the interaction of these

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[1] Tom Burns and G. M. Stalker, The Management of Innovation (London: Travistock Publications Limited, 1961), pp. 96-125.

[2] James A. Mueller and James Brian Quinn, "Transferring Research Results to Operations," Harvard Business Review (January-February, 1963), p. 58.

functions the firm is able to develop an updated corporate strategy consistent with its objectives. The Research and Development groups establish the specific areas in which they should concentrate, remain in touch with, or virtually ignore in the light of current and projected developments from other areas of the firm. This identification provides the basis for the allocation of adequate financial resources to those areas indicated as significant to the interests of the firm.

It is essential that the firm's corporate planning function:

a) Develops a company-wide, long range plan into which research and development activities are properly integrated.

b) Provide adequate commercial information to rank and balance Research and Development activities to meet company goals.[1]

To be effective the firm must consciously consider the following:

a) A re-evaluation of over-all company objectives in light of expected future economic, sociological and technological developments.

b) The particular technological strategy the company will use in affecting these objectives.

[1] *Ibid.*, p. 53.

c) The specific mission of each major research and operating group supporting the company's goals and objectives.

d) Ranking and balancing research and development projects to best meet the company's anticipated technological threats and opportunities.[1]

The Research and Development units or a staff group working in close coordination with these units prepares the technological forecast. A variety of methods exist for their preparation; trend extrapolation uncertainty measures and the Delphi method are among the most common.[2]

Market research activities integrate customer and competitor inputs into the process. Similar projective methods are utilized by these groups to derive forecasts from their research data.[3]

The technological and market forecasts are combined with economic and sociological forecasts prepared by staff groups in the comptrollor or forward planning

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[1] Ibid.

[2] For a detailed analysis of the most prevalent forecasting methods see James R. Bright, Technological Forecasting for Industry and Government: Methods and Applications (Englewood Cliffs, N.J.: Prentice Hall, 1968).

[3] James Brian Quinn, "Top Management Guides for Research Planning," Technological Planning on the Corporate Level, ed. James Bright (Boston, Mass.: Harvard University Graduate School of Business Administration, 1962), pp. 192-95.

areas.[1]

With the above forecasts complete they are brought together for analysis. This analytical integration determines the technology required to insure present product lines and to provide the basis for new products and applications. To accomplish this determination, the forecasts are combined to identify the areas in which change will create demands for technology. Present technology is then compared with the needs to identify the occurrence of technological gaps. The missing facts associated with these gaps are then defined and compared with current progress in fundamental and applied programs. When evaluation is complete it is determined in what areas new or additional effort should be applied. Funds should be then allocated to those areas possessing the highest potential pay off.

The above process is crucial for a firm to be a successful innovator. Effectively performed it facilitates the transfer to commercialization. This is achieved by identifying the truly significant areas of technology

[1]Quinn, "Long-Range Planning of Industrial Research," pp. 90-92.

and allocating sufficient funds to allow pursuit of research in these areas.

iv. Research and Development

a. Information Transfer

Research and Development are key elements in the transfer of scientific and technological information from external sources providing the firm's innovational potential. The large, technologically-oriented firm provides a combination of approaches to assure obtaining information significant to its interests.

A library function is usually established within the firm where published scientific and technical reports, lectures, articles and patents are catalogued and maintained as reference for utilization by individual researchers. Information included in the library may be quite broad but is defined by the vested interests of the firm. The utilization of information varies widely from firm to firm. Some firms pursue a planned policy of disseminating significant incoming information. Others, perhaps the majority, utilize this as a reference facility only;

end product but rather toward the understanding of an area of knowledge.

Fundamental research activities take their direction from the general corporate plan; the amount of funds allocated to this area and the individual researcher's interest in promising areas. The topics for exploration within fundamental research essentially come from the bottom up as the researcher, knowing more about his specialty than anyone else, should be able to identify projects beneficial to the firm.

c. Applied Research

Applied research singles out or identifies scientific knowledge with specific potentials or applications which may provide a base for development of a defined product. Applied research is essentially concerned with the establishment of capabilities.

Research at this stage takes its direction from the over-all corporate plan and budgetary constraints as does fundamental research. However, applied research is influenced to a greater degree by customer and competitor inputs as identified by marketing information. These influences may be communicated through formal or informal interaction between top management, operating management and the Director of Research. These individuals may possess enough information at the time to determine the potential effects which establishment of the capability would allow them to exploit. The possession of such information by the Director of Research enables him to guide Applied efforts into potentially profitable areas. In discharging his directive function the Director of Research is likely to create a more structured environment for the applied researcher.

d. Development

Development activities attempt to reduce a capability defined in applied research to product application and/or determine the correct combination of existing technology for specific product application. Development costs are high as the achievements sought have tangible objectives with a specific end result. This planned process requires the successful completion and integration of many functional tasks to accomplish the desired end result. Thus, there is a high degree of interaction with marketing, production, and engineering groups at the operational level.

The individual engaged in development work utilizes sources of information different than fundamental and applied researchers. He avails himself of relevant published material and patents, but has little contact with others working in the same field outside the firm. He is limited in forming and utilizing external contacts because of the usual requirement to refrain from disclosing information of value to the firm.[1] He therefore leans heavily on the applied researcher and other technologists within the organization for additional information and stimulation.

[1]Mansfield, The Economics of Technological Change, p. 85.

CHAPTER III

THE INNOVATIVE PROCESS

i. General

The process of innovation receives its stimulation from either within or without the research and development functions. Its origin may be a perceived need necessitated by forces external to the firm, such as a scientific advance in a competitive field; or a need in an area of potential profitability as advanced by management of the firm. Innovation may also arise from the curious exploration of individual researchers.

To describe the innovative process in full and demonstrate the transitions which occur, it is feasible to proceed from the fundamental research stage. The same considerations would hold for an innovation arising at another point, the difference being that some steps are eliminated.

ii. Fundamental Research

The researcher may initiate the innovative process by pursuing investigation of a subject within a field of interest to the firm. His initial step is review of past and current work done in the area of interest and its related fields. This is accomplished by drawing on the company's technological library or external references to derive a profile of significant activities in these areas. He then establishes an objective or hypothesis and the approach for exploration. The researcher's experimentation will continue until his hypothesis is confirmed or denied effecting re-evaluation and continuation through additional experimentation.

There is relatively little control at this stage, with the exception that projects be relevant to corporate interests and within set budgetary limitations. When the researcher requires additional funds, manpower, or extended lengths of time to continue his work, the project is brought into the firm's formal review system. Primary consideration rests on the relationship of the effort to the interests of the firm. This is based largely on:

a) The competence of the researcher and his enthusiasm.

b) A determination of what could result if the project were successful.

c) The rapidity of advances generally occurring in that area.

The absence of overly formal review procedures places reliance on the perception of the director of research to adequately appraise the possible significance of the project and its potential benefits to the firm. The project is hereafter subject to periodic review which determines if the rate of progress toward the researcher's goal appears promising and continuance of the project warranted.

The fundamental researcher, or a researcher in any of the research and development activities, may obtain significant results through: planned experimentation; or observation of phenomena leading to unexpected enlightenment. The factor of serendipity in research has been widely discussed and analyzed. Discoveries of this nature are based on luck, but in part only. Usually the researcher is working on a defined question and has devised appropriate sets of experiments to answer the question. The results of the experiments, planned or accidental, are significant whatever their nature. Therefore, serendipity is best considered as "a bonus to the perceptive, prepared scientist and not a substitute for hard work."[1]

Upon achievement of a significant understanding within an area of the company's technological base the innovative process enters the applied research phase.

iii. Applied Research

The initial task at this stage is the determination of capabilities which can be created from the new understanding. A potential source of application is previously expounded needs. If data currently exists on the expected profitability of a capability which can be derived from this knowledge, applied work may begin immediately. More commonly, however, applied research is directed toward areas considered most exploitable by the director of research.

[1] P. H. Abelson, "Serendipity in Research," *Science* (January 17, 1964), p. 1177.

Another significant consideration is responsiveness of the general research group and top management to the discovery. If termed significant, there is usually a high penetration of its existence throughout these groups. This awareness allows additional stimulation for application and a receptiveness for additional funding if necessary.

In appraising the many capabilities which might be established during the applied phase the director of research still acts in an informal manner. The appraisal is similar to fundamental research evaluation, but has additional considerations:

a) If the capability is established are there additional technological bottlenecks which must be overcome to convert the capability to product application?

b) If achievement of the capability is successful will the firm actually be in a better competitive position? Will competitive technology negate possession of the capability?

c) Will establishment of the capability result in an order of magnitude improvement with consequences which are, although not clearly defined, apt to be almost surely profitable?

d) What will be the eventual scope of the applied research effort and its required time to completion?

The project, or projects if a parallel approach is used, will be re-evaluated periodically to assess their progress and determine whether further continuation is desirable.

When a capability is successfully established it moves into the development phase.

iv. Development

Results of applied research are brought into the development stage through two means. One is a request by operating management for development of the capability into a specific product. This product exists in present lines of the firm's business and its integration into operations is quickly appreciated. Secondly, top management may recognize the potential of a new product developed from the capability. Their request initiates developmental efforts anticipating the possibility of the establishment of a new business venture.

Before discussing the development process in full it is wise to note possible resistance often appearing at this stage. Change, or the probability of change, may arouse resistance within individuals not directly concerned with innovation in its early stages. Orientation of researchers and their director is usually in terms of corporate benefits the innovation will provide, while those responsible for operations often consider the potential problems associated with implementation of the innovation. Some specific reasons for this resistance are:

a) To protect social status or prerogative.
b) To protect an existing way of life.
c) To prevent devaluation of capital invested in an existing facility, or in a supporting facility or service.
d) To prevent a reduction of livelihood because the innovation would devalue the knowledge or skill required.
e) To prevent elimination of a job or profession.
f) To avoid expenditures such as the cost of replacing existing equipment or of renovating and modifying existing systems to accommodate or compete with the innovation.
g) Because the innovation opposes social customs, fashions or tastes of the habits of everyday life.
h) Because of the rigidity inherent in large, bureaucratic organizations.
i) Because the innovation conflicts with existing laws.

j) Because of personality, habit, fear, equilibrium between individuals or institutions, status and similar social and psychological considerations.
k) Because of a tendency of organized groups to force conformity.
l) Because of a reluctance of an individual or group to disturb the equilibrium of society of the business atmosphere.[1]

It is crucial that top management be aware of these conditions and exert conscious attempts to insure they do not hinder the innovative process. Although no easy cure-alls to overcome these resistances are available, their effect can be minimized. The creation of a positive organizational environment and planned policies receptive to innovation aspire to this goal.

Entry into the development phase is accompanied by an initial screening, technical-economic analysis. Compared to the evaluations mentioned previously this screening is highly formal. It attempts to determine the product's anticipated profits and required investment as related to the projects probability of success. A method which may be applied to accomplish this screening is Ansoff's figure of merit. This approach is quantitative,

[1]James Bright, Research, Development and Technological Innovation (Homewood, Ill.; Richard D. Irwin, Inc., 1964), pp. 131-32.

based on estimates available from the limited data usually possessed at this time.[1]

The result of subjecting a proposed development project to Ansoff's process is that it:

a) Provides a mechanism for anticipating costs and problems which can arise in the process of development.
b) Permits a relative ranking of competing development projects.
c) Makes possible a comparison of development to other areas of research.
d) Places product development within the over-all business perspective of the firm.[2]

If the project passes screening, the director of research authorizes funds for its development. The development initially utilizes scientific and technological knowledge, often drawn from the firm's reference facility, to identify problems, and thereby design and analyze critical experiments to assure the physical possibility of the desired product. With this possibility established the developer generates one or more possible physical designs. At this stage a detailed technical-economic analysis is usually conducted. The analysis

[1]For full explanation of this method see H. I. Ansoff, "Evaluation of Applied Research in a Business Firm," _Technological Planning on the Corporate Level_, ed. James Bright (Boston: Harvard University Graduate School of Business Administration, 1962), pp. 209-26.

[2]_Ibid._, p. 219.

considers the following:

a) Financial Aspects
   1. Pre-tax return on investment.
   2. Estimated annual sales.
   3. New fixed capital payout time.
   4. Time to reach estimated sales volume.

b) Development Aspects
   1. Development know-how required.
   2. Probability of success and time to accomplish.
   3. Patent status.
   4. Development investment payout time.

c) Production and Engineering Aspects
   1. Required size of operation.
   2. Raw materials.
   3. Equipment.
   4. Process familiarity.

d) Marketing and Product Aspects
   1. Similarity to present product lines.
   2. Effect on present product lines.
   3. Marketability to present customers.
   4. Suitability of present sales force.
   5. Number of potential customers.
   6. Market stability.
   7. Market trend.
   8. Technical service requirements.
   9. Market development required.
   10. Promotional requirements.
   11. Product competition.
   12. Product advantage.
   13. Length of product life.
   14. Cyclical and seasonal demand.[1]

The preceding format serves a dual role. It allows ranking for selection and provides a quantitative basis for re-evaluation of developmental proposals, it establishes

[1]Bright, Research, Development and Technological Innovation, pp. 403-14.

the general considerations to be fulfilled for successful product commercialization.

Upon passing the detailed evaluation the product's design components are analyzed to specify characteristics of its subsystems, components and materials.

> The basic design concept is qualitative and schematic and it is therefore necessary to proceed by concept analysis to test through the various areas of uncertainty until one apparent solution is found for each problem. A preliminary design emerges, which together with the related analysis and experimentation affords a detailed design of a working prototype. Instructions are formulated for the purchase of material, the construction of components and the assembly of the prototype. A detailed design is at times initiated parallel to the preliminary design, but its work is subject to constant correction as the preliminary design evolves. When the design is finalized, proposed changes are rejected if they cause delay. The prototype is constructed and tested; altered to eliminate defects and tested again.[1]

During the above phase the Development personnel have constant interaction with marketing, engineering, and production individuals and groups, enabling them to develop a product which can be effectively commercialized. The nature and frequency of these interactions are largely governed by the time required for completion of the

[1] Mansfield, The Economics of Technological Change, pp. 47-48.

development and the probability of its success.

With the resulting reproducible prototype in hand, a market test is conducted prior to the final technical-economic evaluation of the development stage. As a result of the additional information gained during this market test any necessary design changes will be made. The product is then appraised, similar to the process described earlier, and the decision made whether to continue from development into operations.

v. Transfer to Operations

The transfer from development to operations is the last and most crucial stage of the innovative process. Its successful implementation is the key to obtaining the promised profitability upon which the product has progressed this far.

The commonly utilized methods to effect transfer are movement of the product into an operating division, a new products division, or to establish a separate and continuing business venture.

The transfer may be requested by the aforementioned divisions due to its desirable profit potential, or directed into one of these units by top management. The concept embodied in each of these methods is to provide a function effectively coordinating the activities of sales, production and development. The establishment of a group with product orientation and responsibility achieves a sense of unity and purpose which eases the transitional phase. Regardless of the specific nature of the group it must insure:

a) The transitional phase is adequately planned from development to commercialization.

b) There is a basis for controlling the transfer through its cycle.[1]

Two methods effectively utilized to achieve these requirements are the establishment of P.E.R.T. networks and budget reviews.

P.E.R.T. networks permit the individual charged with coordination to identify the specific tasks required, timing of these required tasks, and dollar requirements to accompany each stage. With possession of this information the individual responsible is able to assemble the functional specialists necessary at the correct times and determine

[1] Mueller and Quinn, "Transferring Research Results to Operations," p. 63.

the basic personnel required for continued operation upon achievement of a stable production function.

Budget reviews supplement P.E.R.T. charts to allow periodic appraisal of the project's progress. This process brings key individuals involved in the implementation together at defined stages during the transitional phase. The periodic review allows the coordinator to determine if costs being incurred are approaching or exceeding expenditures planned at that stage. The review has the further advantage that those most intimately concerned with the project can participate in assessing its progress. Thereby, it is relatively simple to effect a re-orientation of activities if deemed necessary.

The coordination of transitional activities continues until the product is stabilized in an operational sense. As problems are solved, the functional specialists assembled are re-oriented to other assignments. Remaining individuals provide the basis for the operational organization required to conduct routine business activities.

The rudimentary outline presented in this chapter describes the process of the transfer of technological information to commercial application. It is a format forcing critical examination of the relevant factors and influences of the commercialization process. It is not necessarily the optimal method of innovation for all firms.

> Each management must analyze its own organization, its particular objectives and its strategies. Then it must tailor a transfer system to the company's needs. However, if it is to accomplish this effectively, it must consider all the factors and considerations presented here. Unfortunately --in the past--too many managements have not.[1]

[1] *Ibid.*, p. 66.

CHAPTER IV

THE CORNING GLASS WORKS

i. History

Corning Glass Works, an industry leader in glass and glass ceramics,[1] originated with the attempts of its founder, Amory Houghton, Jr., to commercially improve railroad signal lamps. In these and subsequent attempts at commercial success, Houghton called upon scientists to assist him in resolving problems hindering his attempts at commercialization. His son carried on this tradition and formally recognized the value of scientific research as a function of business.

From initial activities dealing in signal lamps and battery jars evolved a growth company reporting 1967 earnings of $50 million on sales of $435 million.[2] The annual compounded rate of growth over the last five years, including 1967, has been 10.7 percent in sales and 12.2 percent in earnings.

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[1] By comparison of Table 4 with Table 1 it is seen that Corning's sales account for approximately 40 percent of the Pressed ang Blown Glass Industry (excluding container manufacturers).

[2] For Corning's development over time consult Table 4.

Corning supplies markets including: construction, lighting, manufacturing, communications, medicine, science, food preparation and serving, and transportation. The thousands of products sold these markets utilize the unique properties of Corning's glass and glass ceramic materials. Corning currently employs 23,000 people in 53 plants and 26 sales and service offices throughout the world. It has additional associate interests in seven foreign and two domestic glass corporations.

ii. Goals and Strategies

"The primary purpose of Corning Glass Works is to pursue excellence in glass world-wide, making this family of individuals, its related products and corollary technologies the most unusual and useful in our civilization."[1] To accomplish this objective Corning aspires to:

a) Reach for new market opportunities whenever its technology can be made useful and provide a significant benefit to that market.

b) Further penetrate its established markets by application of the unique properties of glass and related technologies.

[1]Written statement of Corning's 1968 objectives.

c) Grow at a rate of 10 percent annually in both sales and profits.

d) Achieve the above through the vigorous continuation of a large and expanding program of research and development.

Corning's strategy to accomplish its goals has been an historical evolvement. Corning's early successes, based upon application of scientific solutions to commercial problems, have established the profits necessary for Corning to develop a respected and productive research and development facility.

The company's willingness to back up its strategy of internally generated growth is indicated by the facilities and research budget it provides for this function. Corning established one of the nation's first industrial labs in 1908, occupying 1,200 square feet. In 1939 a new building of 66,000 square feet was constructed. In 1957 a complex of 189,000 square feet was built and in 1965 a structure of 400,000 square feet was completed.

An examination of the growth of Corning's research budget, as compared to sales in corresponding periods, further indicates Corning's commitment to achievement of objectives by these means.[1] Corning's 1963 expenditure of $15.4 million was 5.3 percent of sales. This is higher than the average for all manufacturing industries in the United States and considerably above the 1.6 percent of sales which Owens Illinois, a primary competitor, spent on research.

Thus, Corning bases its plans for the future on the assumption that support and exploitation of an intensive research and development program which develops superior technology can generate profitable new products. Growth, through internal generation of new technology, further requires Corning to underwrite its costs by the ability to generate sufficient funds out of current lines of business. Corning therefore moves into markets in which its materials make unique contributions for which it can obtain prices sufficient to maintain a gross margin estimated at 40 percent.

[1] See Table 5 for the development of Corning's research budget as a percentage of sales over time.

iii. Organizational Environment

a. Structure and Philosophy

Corning is best described as a large, decentralized, highly departmentalized, rational-organic organization. It is an organization responsive to creativity and change by the very nature of its rapid rate of internally generated growth. Its goal of 10 percent annual growth in sales and profits has been achieved with the result that Corning has doubled its size in the last seven years.

Corning's formal structure is revealed in Exhibit 1. There is a great awareness of the necessity for change which permeates the organization at all levels. Each specialized unit is aware that it relies upon the others to achieve the successful completion of innovative projects. The awareness allows each unit to act as an expert member of a well-functioning team. This atmosphere is consciously promoted by giving all responsible 100 percent credit for success rather than distributing credit on the basis of percent contribution to a project.

Corning's formal structure attempts to force decision making downward to allow those most affected to have a major voice in its formulation. There are the normal checks within the system and an established chain of command, but it is important to note that the individual charged with a responsibility is left largely to his own means for accomplishment. This results in wide interaction between and some overlap among differing groups seeking to discharge their responsibilities. There exist few written procedures to assist a manager in fulfilling his charge; it is rather something learned and internalized during his career development at Corning. The formal structure exists to insure the necessary responsibilities will be discharged but it is assumed that having to resort to strict utilization of formal channels is not the most effective means of accomplishment. The manager is expected to utilize informal methods as well, as top management realizes this is a more effective and rewarding way for the managers and thus the company to achieve their objectives.

The remainder of this section will view the organizational units intimately connected in the innovative process at Corning. They are: Top Management, Corporate Business Development, the Technical Staffs Division, Operating Divisions and New Business Development.

b. Top Management

Top management at Corning consists of two groups: the Triumverate (Chairman of the Board, President, and Director of Technical Staffs) being one; and Vice Presidents and General Managers of Operating or Staff Divisions being the other. The interaction of these groups with their markets, external environments and each other sets the general direction in which Corning moves to accomplish its objectives. The second of the above groups is intimately concerned with deriving specific approaches within these general directions.

A moment's digression is worthy to examine the Triumverate which is somewhat unique in this corporation. The Chairman of the Board, Amory Houghton, Jr., is Corning's chief administrator, largely because his family founded the firm and holds the majority stock interest in

Corning Glass Works. He has in effect delegated operating responsibility to the President and forward planning responsibility to the Director of Technical Staffs. The interaction of these individuals with their subordinates, in a relatively informal manner, has had profound effects on the direction of the corporation. One example is Corning's strength in glass program. It was initiated by informal communication to the Director of Technical Staffs by stating, "Wouldn't it be nice if we could make a glass that wouldn't break?" From this casual comment Corning established its strength in glass program, which in the last ten years has developed over twenty different methods for strengthening glass; CHEM COR perhaps being commercially the most successful thus far.

c. Corporate Business Ventures

Corporate Business Ventures is the function Corning has established to appraise its external environment. It has as a major responsibility corporate forward planning. This function assures coordination of the Divisional Manager's individual five-year plans into areas consistent with Corning's objectives. This coordination is not a directvie process in the manner which is commonly assumed. Rather it appraises the external environment's current and projected economic, competitive and sociological effects on the corporation. Through analytical and projective techniques of its own and a close interaction with divisional marketing groups, corporate forward planning establishes a common format which tells division managers how to plan; what factors should be considered in developing their individual strategies. This process allows those closest to the market to formulate their own plans while establishing a common format assuring the Divisional Managers, and thus the company, are all moving in the same general direction.

In light of the aforementioned, this group through its market planning and acquisitions departments, appraises new businesses which may be profitable for Corning to consider.

d. Glass Top

A recent development within the Corning organization also serves to give direction to the companies forward planning activities. A Glass Top conference is conducted every three years under the auspices of the Manpower Development Department. This conference of Corning's Top Management retires to a peaceful location and looks at the future; the world external to Corning and Corning's role in that world. The larger group is broken into smaller discussion groups by areas of interest and/or competence which pursue any topic within this loose framework they so desire. The smaller groups report their appraisals to the larger body which attempts to generate a consensus on where Corning should be going, how to get there and what to watch out for on the way.

e. Technical Staffs

1) General

The Technical Staff's over-all responsibility is the development of superior technology to keep Corning in the foreground of world-wide glass development. It specifically seeks to provide the technical assistance to make existing business flourish; provide the technology required to establish new business in new or existing areas of company interest. Its over-all funding of activities is roughly 50 percent research and 50 percent development. This is intended to insure that Corning does not: accumulate technology with which nothing happens; spin its wheels trying to develop ideas without an adequate supply of capabilities.

The Technical Staff's group conducts fundamental and applied research in areas deemed within the company's general interest or areas researchers identify as relevant to Corning's interests. Corning's interests are given direction by individual researchers, the Director of Technical Staffs, Top Management and divisional requests for technical assistance.

All development work provided by this central Technical Staff is initiated through formal divisional request approved by the Director of Technical Staffs. The

Request For Technical Assistance (R.F.T.) initiating work on development of a capability or specific product development includes divisional marketing data. This data establishes an indication of the market opportunity and resultant profitability to be obtained by Corning if the capability or development are successfully achieved. Considerations taken into account in granting approval of a R.F.T. by the Director of Technical Staffs, Dr. William Armistead, are:

a) Size of market opportunity.
b) Consensus of its appropriateness by top management.
c) Availability of an approach to its resolution.
d) Major exploratory work required to reach the point where an approach is possible.
e) Competency and availability of researchers in this area.
f) Current work being conducted in this area.
g) Intuition and feel for the proposal.

It was not determined how these variables are weighted by Dr. Armistead. However, whatever means are used, the power of allocation which effectively establishes priorities gives the Director of Technical Staffs perhaps the greatest power within Corning to determine its future direction. It has been advanced that Dr. Armistead acts as Director of Technical Staffs, Director of Forward Planning, and Director of New Business Development since he controls all technical resources of the company which could be used to pursue a technological development. If he does not assign people to work in a certain area or rejects a divisional R.F.T. he in effect determines that Corning will not move in that direction.

2) Organization

The Technical Staffs Division is organized into four major departments as seen in Exhibit 1.

a) Administrative

The Administrative department provides a support function for the remaining technical groups. Its relevant functions are Corning's Technical Information Center, Technical Liaison, and International Liaison. In addition, it provides labs for analytical measurement and instrument creation as required by the other technical departments.

Corning's Technical Information Center (T.I.C.) is the literature input upon which its researchers draw. It has responsibility for cataloging periodicals, articles, and patents relevant to Corning's interests. T.I.C. provides a library function for researchers and may disseminate information to individuals if considered to have a major bearing on their activities. T.I.C. generates a technological profile of an area at the request of a researcher. This provides him with information on past and current findings in that field, related patents, and developments anticipated in the area.

The Technical Liaison deals with analysis of, and personal contact with government, university, and private research institutions. The International Liaison function is concerned essentially with the same interests but on a world-wide basis.

Both liaison activities are primarily concerned with identifying the centers of excellence in glass technology. Through attendance at meetings, visiting university and private labs, and following personal contacts it is hoped Corning will gain insight into areas possibly dovetailing with its interests. The individuals performing the liaison pursue the responsibility under their own direction or are sent on specific assignment to delve deeper into certain developing areas.

In addition, these individuals are constantly alert to an inventor or individual who has an idea far enough along to be patentable in the near future. If Corning is interested it may offer monetary assistance, or the use of its facilities and knowledge to assist the development. The hope being to get in on the ground floor through license, purchase or absorption of the individual and his invention.

b) Research

1) Fundamental Research.--Fundamental Research is directed by the influences mentioned previously, the Director of Technical Staffs and his interaction with the individual researcher, guided by the company's general areas of interest. Specific proposals are most apt to originate with specialists in a field, essentially, from the bottom up.

2) Applied Research.-- Applied Research takes its direction, in addition to influences mentioned earlier, to a greater degree from the Director's perceptions of beneficial capabilities and Divisional R.F.T.'s. Here an individual researcher may explore areas of personal interest for approximately one week, but if to continue longer his project is subject to review by the Director.

c) Development

Corning's development activity is highly directed by the Divisional Managers as all work done is by approval of R.F.T.'s initiated by them, based upon marketing data. Corning's development activity works closely with the operating division's market development group in defining material and production specifications for the item under consideration.

There exists acute responsiveness with the Technical Staffs Division. The flexibility of its over-all budget, whose specific allocation is left in the hands of the Director, allows a shift in emphasis as conditions change. The Director may shift people or projects as long as he balances out to the total research and development allocation at year's end. This flexibility allows for rapid attention to projects that may become hot items without the necessity of waiting for formal channels of funding to clear.

An example demonstrating this flexibility is the development of the Corning P.H. Meter. A. C. Beckman, a primary supplier of this item to distributors to whom Corning supplied other items, decided to exclusively distribute products through establishment of its own field sales force. This left a void for P.H. Meters within the distributor's market. Since Corning possessed the technology required to create a P.H. Meter, Dr. Armistead set a development group to work immediately upon receipt of this marketing information from the Division Manager. Within two months a prototype was available, distribution beginning some eight months later. The Corning P.H. Meter is now the acknowledged standard of the industry.

d) Engineering

The engineering function is concerned primarily with process research in melting technology, engineering technology, and machine research. Such processes are for the most part aimed at cost reducing innovations and will not be discussed here.

f. Operating Divisions

Division Mangers are the individuals within Corning responsible for charting the specific course of action within the general direction of company interest. The divisions are decentralized, highly autonomous, and competitive in nature. The division managers must obtain margins on current product lines sufficient for them to undertake development of products and markets to assure the division's, and the company's, future profitability. These divisions ultimately compete for the capital funds necessary to transfer operations from development to production.

The divisions are the dominant source for the influx of marketing information into the company; the philosophy of Corning being that these are the men on the "firing line"; those closest to the market who deal in it daily and therefore should be best able to judge the development of Corning within the market. The division managers, through their market development groups, translate customer needs and desires into potential product proposals. On the basis of this information market opportunity is identified and the technology required to exploit the opportunity defined. This information provides the required data for the R.F.T. to be sent Technical Staffs requesting a capability or product to be developed.

g. New Business Development

New Business Development is an operating division reporting directly to the President. This division is responsible for developing businesses currently on the fringes of Corning's interests. These new businesses are either not related to established divisions in the company or require some time to mature into their full potential. New Business Development is highly responsive to Corporate

Business Development, Top Management influence and applications of research.

New Business Development searches for an runs businesses in new entrepreneurial areas. It is responsible for their profitability and the establishment of an organization to effectively carry on normal business activities. It competes for capital funds on the same basis and by the same procedures as other operating divisions.

It currently has small businesses established in hydrospheres and chromotography.

iv. Communication

Methods of communication utilized by these diverse groups to inform each other, whether formally or informally, are based upon establishing the involvement of others in their activities.

a. Period Review Meetings

Obtaining involvement is most consciously promoted by each division's period review meeting at which the directors and managers of Technical Staffs attend. During these meetings the Technical Staffs personal get a feel for what is going on within the operating divisions, their markets, and their problems. The period review meetings allow the divisions to have specialists on hand to advise and inform them if technological solutions to their problems are possible, or under way in the Technical Staffs Division. The Technical Staffs representatives further discuss the status of all R.F.T.'s the division has in process. This allows for first hand exchange of any new developments, either in the lab or market, that may be occurring which calls for a reorientation of activities by these groups.

The activities conducted during "meeting week" have overtones of vying for position in the eyes of the Technical Staff. These individuals are intimately connected with the allocation of technical resources upon which the divisions rely for their continued profitability. Therefore, a conscious attempt is made through social activities, supplementary to formal meetings, to "stay on their good side." These additional efforts attempt to encourage Technical Staff personnel to give continued attention to their division's projects. By informing and involving the Technical Staffs personnel it is further hoped they will key into something in conducting their normal activities which the division might utilize for commercial application.

b. Technical Staffs Semi-Annual Project Reviews

These reviews, to which all division managers and concerned subordinates are invited, are formal status reports. Each researcher presents a technical paper on the intentions of his research, where it stands, and what he proposes to do in the next six month period.

c. Monthly Summaries of Reports on Progress of Research and Development Activities

These summary reports, in written form, are widely distributed throughout the company. They inform and alert individuals not intimately connected with a project, of activities underway which may be of benefit to them.

d. Follow Through on R.F.T.'s

Once an R.F.T. is in process there is usually someone from the division assigned to the project working with the researcher in Technical Staffs as a liaison with the division. There is further informal communication between those divisional personnel and Technical Staffs personnel who are intimately connected with the development initiated by the R.F.T. These communications occur on a daily, or whenever required, basis.

e. Memos

With the high degree of awareness existing at Corning one individual may gather information of importance to another. He may note this information in a memo to the appropriate individual. This is a highly informal but practiced method of communication at Corning.

v. Innovation

The process of innovation receives its primary stimulation from any of the sources previously discussed. If initiated at the divisional level the marketing data required for the R.F.T. will have been collected prior to its inception. When occurring at the research level the potential innovation is picked up by a division, through the communication process already discussed, and market research conducted at this time.

Divisional marketing data will concern itself with identifying: the market opportunity, the product's specific range within the market, benefits of the product to the market, and the relation of the product to competitor's products and consumer desires. The marketing information is collected by conducting opinion and attitude surveys from selected consumers through panel, market, or questionnaire techniques.

In addition to market data the R.F.T. will specify any restraints within which the division requires the product to be developed. These include such elements as melting temperatures, tank requirements, etc.

Upon approval of the R.F.T. the Technical Staffs pursue development of the product in accordance with the specifications and restrictions as provided by the division.

For major development the division establishes a project manager who reports directly to the division manager. The project manager has responsibility for coordinating development activities and implementing transfer to operations.

The Technical Staffs apply all functional specialists required to develop and perfect the product, and its related processes, for volume production operations. These individuals define the product's general production specifications and operating procedures.

Concurrently, division personnel begin design work and derive proposals for attitude tests. These test results are analyzed and a final design established. The final design determines the final production specifications and operating procedures to be created by the Technical Staffs.

Once a design and method of production have been formulated and made possible, a production run of the product is made for sales testing. The sales test results provide the basis for the decision to continue the project, and additional figures necessary to prepare an appropriation request for capital funds.

If the project is continued and capital funds appropriated, a major production run is conducted for market test activities. The market test, as the prior sales test, provides additional figures and confidence levels upon which the decision to proceed into full production operations will be made.

If continued, the project manager will establish the productive capacity, organization required for operations and begin a national roll-out of the product.

CHAPTER V

THE CORNING WARE CASE

i. Exploration and Discovery

CORNING WARE, one low expansion application of PYROCERAM brand glass ceramics, originated in the curiosity of Dr. Don Stookey. During the late forties Dr. Stookey's interest had followed Dr. Robert Dalton's research on the photosensitivity of glass. Dr. Dalton achieved in his research the ability to create patterns in colored glass by heating selected parts of the glass to different temperatures. By exposing this glass to ultraviolet light and reapplying heat he could achieve further deepening of color.

Stookey's curiosity of this phenomena caused him to question the occurrence of these results; what actually happened to the composition when the ultraviolet rays struck which would allow for the further darkening of color? This inquiry led Stookey to examine the chemical composition of Dalton's glass with a detailed analysis of the chemicals added to its basic glass ingredients. Two ingredients isolated as critical were cerium and silicate of copper. Through vigorous experimentation, Dr. Stookey determined that upon application of ultraviolet light, cerium underwent a photochemical change freeing electrons to group around copper ions deposited by the silicate of copper. These groupings were nuclei of crystals frozen in place until the glass was heated again. Upon reapplication of heat, Stookey found that other chemicals were freed to gather around these nuclei, forming an even cloud of crystals through what, up to that time, continued to be glass.

With an eye on commercial application, Dr. Stookey utilized this process to create pictures in glass. By using a photographic negative to control exposure of the chemically-seeded glass he achieved crystallization of those exposed areas while the unexposed remained in a glassy state.

Work on composition, process and product development was begun to exploit this research. Concurrently, the development of the television bulb market occupied a major share of Corning's attention. During a discussion with Dr. Littleton on problems arising from exploitation of this market, Stookey was informed that a major problem existed in drilling three, small, concentric holes in the bulb envelope. This stimulation spurred Stookey to apply his research to resolution of the problem.

Knowing his method could cause adjacent areas of material to have different chemical composition and density led him to postulate they should react at different rates when exposed to acid treatment. He therefore blocked out dots on a photographic negative and exposed it and a piece of his material under an ultraviolet light. He then heated the glass and obtained a plate with crystallized dotted areas. This plate was subjected to a bath of hydrofluoric acid. From this bath it was discovered that the crystallized areas dissolved 10,000 times faster than those unexposed.

This realization stimulated Stookey's efforts further. During this further experimentation, in the fall of 1952, the historic accident occurred giving birth to PYROCERAM brand glass ceramics.

A furnace controller during the re-heating cycle of a piece of exposed photoformed glass allowed the furnace temperature to rise 300 degrees higher than was scheduled, to 900 degrees. Stookey, annoyed at this error, opened the furnace expecting to find a pool of melted glass but instead was confronted with a plate of opaque, predominantly crystalline material much stronger and harder than the original glass.

From this accident and the meticulous series of experimental repetitions which followed, Stookey realized he was no longer dealing with glass but a new crystalline substance possessing entirely new properties. This realization focused his attention on the process of controlled crystallization involving thermal nucleation and elimination of exposure to ultraviolet light. During this phase of experimentation, Stookey realized how wide the range of possible glass ceramic compositions might be and the significance of this to Corning.

In appraising the significance of his discovery with the Director of Research it was determined that Stookey's work was a fundamental breakthrough in technology. Being a discovery of this nature dictated that rather than yield to the temptation of concentrating on product development it was an absolute necessity to establish its limiting parameters. Therefore, Stookey headed a group to explore differing compositions which would allow establishment of the parameters for patent application. It was consciously considered that the most important area of future commercialization might lie in an area not yet defined as within these limits. Thus, rather than file a limited patent and effectively excluding Corning from potential markets, a major program of composition research was undertaken.

During the next three years Stookey and his group identified over 100 different compositions of PYROCERAM glass ceramics, which served to establish the sought parameters and were included in the patent application.

ii. Climate

The impact of television on Corning's sales and profits during the late fifties had stabilized, causing concern within the corporation about the direction of Corning's future growth. Chairman of the Board, William Decker discerned Corning's traditional posture as primarily a supplier of original equipment manufacturers severely limited the company's future growth potential. He, therefore, began to accentuate Corning's consumer orientation and policies toward forward integration. Consistent with this reorientation, he brought Mr. R. Lee Waterman into the company as General Manager of the Consumer Products Division. Mr. Waterman's broad marketing background and consumer orientation was an attempt to interject new blood into Corning's relatively small Consumer Products Division.

During the period in which Stookey and his group were defining compositions, Waterman began activities to strengthen the Consumer Products Division. He directed his initial activities toward enlarging the market for his major line of PYREX oven ware. Through promotional, design and product improvements, this line was substantially bolstered, adding significant profit to the division's performance.

In his attempts to improve the PYREX line, Waterman had requested the Director of Research, Dr. William Armistead, have his people improve the qualities of thermal expansion possessed by the PYREX top-of-the-stove-line. PYREX cooking ware worked well when placed in the oven and surrounded by fairly even heat, or on top of the stove if it contained a sufficient amount of liquid to dissipate the heat and temper the thermal gradings. However, PYREX was inadequate for use over a direct burner or under a broiler, thus restricting the line from a major segment of the cookware market. At Waterman's request, Armistead had assigned a small group to work on improving PYREX qualities of thermal expansion.

iii. Application

With the patent application filed, Armistead directed Stookey to work toward developing two compositions for product application: a dielectric composition for radomes and a low expansion material for possible consumer application. Although these were parallel efforts, the Radome application received the initial concentration of effort, as Corning was under government contract for the development of a Radome. The development of a dielectric composition of PYROCERAM, in the spring of 1956, was the first practical application of Stookey's discovery.

With composition efforts on the Radome development approximately complete, Stookey began to explore the low expansion composition with greater effort. Once he refined the composition to the point at which a zero expansion PYROCERAM was possible, Armistead and Stookey informed Waterman in January 1957 that a solution existed to improve the range top line of PYREX ware.

Waterman grasped the significance of this development and immediately requested Armistead to accelerate the program of material development. Concurrently, he set his divisional marketing and product development personnel to work conducting market research and design activities, to determine the most feasible products to be made and to check their manufacturability.

From this point, until the first volume CORNING WARE production run eighteen months later in 1958, "things really happened fast."[1] Two major parallel efforts began at this time: Dr. Armistead assigned a group under the direction of Mr. Ray Voss to work with Stookey and develop the low expansion PYROCERAM into a top of the stove line; Waterman assigned the Consumer Products Development group under Tom Trusselow to work on divisional aspects of the development.

Voss's initial concern was to redefine the needs of the Consumer Products Division. Through interaction with Waterman, Trusselow, and Stookey it was determined that Stookey's low expansion material must be chemically inert, have an impermeable stain resistant surface, resist erosion, have close to zero expansion, possess certain mechanical strength, have a viscosity curve within a certain range to utilize existing pressing methods, and be able to be melted with existing refractories.

Voss's work to develop the material and its general

[1]Mr. Ray Voss during interview.

specifications for product application led the group, in conjunction with Stookey, to explore a transparent as well as an opaque PYROCERAM. The rationale behind this being that an advantage of the glass business is producing vessels through which one can see. By making cooking ware opaque it was feared the loss of this advantage would cause the consumer to judge it no better than stainless steel or cast iron cookware. The exploration was resolved in favor of the opaque composition, as a transparent PYROCERAM could not be developed. With this decision made, Voss's and Stookey's people refined the opaque low expansion PYROCERAM material to the point where test bars meeting the aforementioned requirements could be drawn. These melts were conducted under Dr. Ben Allen's melting group. From this point Voss's and Allen's activities involved a scaling up of operations to pot melts in the B&C factory and finally a day tank melt in the same factory.

While Voss discharged this responsibility, Tom Trusselow's product development group was pursuing its charge. This group received much of its direction from the involvement of Mr. Waterman, who, realizing the importance of this operation, supervised it closely, applied his marketing experience freely, and acted as a major force in developing the total rationale of CORNING WARE.

Trusselow's initial activities consisted of applying the general specifications developed by Voss to specific product configurations. Being familiar with the market at which the product was aimed through PYREX sales, the group reevaluated the potential in the top-of-the-range segment. The reevaluation indicated a multimillion dollar market opportunity existed which served as a base from which the CORNING WARE product rationale developed.[1] The original conception of the range top line was one to be designed as modernly as possible without jeopardizing the PYREX oven ware line. Therefore, the pricing and design of the line was to be distinctive so it did not relate to PYREX oven ware. If competition with the oven line occurred, it would merely take profits from one line at the expense of the other, resulting in no gain in

[1] From a comparison of Table 2 with Table 3 it is seen the total market in 1965 was approximately $100 million.

Corning's over-all profitability.

Having market knowledge of the most popular selling range top items and a material with unique properties, the most feasible entry point into the market was determined to be through skillets and saucepans. Beverage makers and large items were eliminated from initial entry as Corning had no workable forming method available to develop into a process of manufacturing.

The "squarical" shape of CORNING WARE was established by the realization (Waterman's) that food marketing at this time was rapidly moving into frozen food distribution. The square packages dictated that sizes should conform to those package shapes found popular and readily available, rather than the standard one or two quart sizes commonly used.[1]

With the above concept defined the designers were free to apply their skills to designing aesthetically appealing square shapes. As the designers moved toward this goal and obtained feedback from Voss's developmental efforts, additional considerations became important.

[1]For a complete discription of CORNING WARE see Appendix containing Product and Market Description; CORNING WARE, p.

The designers' awareness of the material's functional qualities required them to exploit its ability to cook, serve, and store. Their further knowledge that the consumer was additionally attracted by appearance gave significant importance to beauty. To maximize the reinforcing effect of the product's beneficial qualities, the china-like qualities of the white opaque composition were deemed important. However, some feeling prevailed that the consumer might be reluctant to utilize a piece of cookware of china-like appearance over a direct flame, as it was something by nature alien to her. Waterman's decision was that an aggressive promotional program would overcome any such resistance. The most effective marketing approach would accentuate the product's unique benefits for cooking, serving, and storing in a truly beautiful vessel, combined with a program of consumer education telling how to most effectively utilize the ware.

With this question resolved the designers considered the additional problems of cover and handle requirements. Versatility of the ware was the basis upon which the decision was made to utilize a detachable, plastic handle. Since CORNING WARE was to be utilized in a triple capacity it was essential that it meet the aesthetic and functional requirements of each. For storage, compactness was essential. This indicated the unacceptability of an attached handle which would waste storage space. Serving requirements dictated poor reception of an attached handle from an aesthetic standpoint if placed on the dinner table. These considerations were reinforced by the fact that the detachable handle was easier and cheaper to manufacture.

The resolution of the cover problem was perhaps less clear-cut and more controversial. Two schools of thought existed within the department at this time. One felt the cover should be clear allowing the housewife to see what was cooking; the other felt that since it would steam over anyway it should be opaque to enhance beauty and maintain product integrity. This boiled down to a clear conflict between costs and product image. If the covers were clear they would have to be made of PYREX material as no transparent PYROCERAM was available. While less expensive from a manufacturing standpoint it was feared PYREX covers would infer a connotation of cheapness to the product. Further, the incompatibility of this material with the promotional claims to be used were feared to have a negative effect on sales. The second school of thought offered the theory that while opaque covers were harder and more expensive to manufacture, they enhanced the beauty of the product and were an honest design solution for product integrity. Both designs were advanced and carried through to opinion, attitude and sales tests, after which Waterman decided in favor of clear covers on saucepans and the option of clear or opaque covers on skillets.

With the basic design complete, the development department accelerated its program of carefully condensed market research. Models were placed in the Corning Glass Works Opinion Center and discussed with selected panels of housewives in Corning's Elmira test area. Service tests of items pressed in PYREX shapes from day tank runs were also conducted in the Elmira test area.

On the basis of the confidence levels generated from these test results, Waterman moved development activities into their next phase. This phase consisted of having the Consumer Products Development Group develop enough production tools to obtain samples for sales testing; Voss's group define specific requirements for production, strength, and durability repetition in production kilns, and decoration procedures; Dr. Ben Allen's melting group establish production requirements for forming, melting and manufacturing of the glass; Dr. George Bair's engineering group determine the engineering requirements, tank construction, and forehearth requirements for production; utilizing Clark Crawford as coordinator of these diverse activities toward establishing a production capability for CORNING WARE; while Waterman began selling the CORNING WARE concept to top management.

The fruition of these individual group efforts was a production run for a sales test in early 1958. Although the solutions for many problems had to be found by these groups, prior to the run, none had proved unsurmountable. The production run was conducted on short mold sets at A Factory's 2-a-Tank. From this run, enough quality ware was obtained to conduct a sales test in Rochester, New York. As is normal in conducting an initial production run of this scope, new problems were encountered and some solutions for anticipated problems proved inadequate. The critical problems arising were:

a) Rapid deterioration of molds due to higher glass temperatures.

b) Chords in ware requiring redesign of forehearth and stirring methods.

c) Rim discoloration from fire polishing.

d) Inability to maintain consistent strength and expansion tolerances in production kilns.

e) Inability to establish efficient pressing operations due to unfamiliar glass viscosity.

To resolve these and other problems occurring, specialists responsible for each function worked closely with operating personnel, basically on a one-to-one basis during this run. Upon completion of the sales test run the results obtained in each functional area were analyzed to determine what improvements could, or would, have to be made if the operation were to proceed into a volume production operation. These appraisals and reevaluations were coordinated at weekly meetings conducted by Clark Crawford.

The Rochester sales tests of CORNING WARE proved favorable, establishing higher levels of confidence in the success of CORNING WARE. The documented sales figures confirmed the projections established by the Consumer Products Division. By analyzing these sales figures against total sales for cookware in the city and projecting them to a national basis, the expected level of sales and required productive capacity was determined with a high degree of credence. This test produced additional information of significance. Not only did the expected sales levels mature but the price at which each item could be sold was higher than anticipated. Saucepan sales were higher than projected; even greater than skillet sales. Skillet sales were as projected in the ten-inch size but less than expected in the smaller sizes.

On the basis of the documented figures and additional information, the initial line of CORNING WARE was to be circumscribed to three items: a ten-inch skillet and a small and medium size saucepans.

With cost and sales data in his possession Waterman was convinced of the economic desirability of this venture, but faced the crucial task of obtaining capital funds for its completion. Up to this point all development costs were expensed out of operating budgets. Now, mold sets, presses, tank construction and possibly entirely new plant construction required capital funds. It was essential that Waterman obtain a commitment of the company to the total CORNING WARE package at this point. The commitment and the establishment of involvement was necessary as the scope of the venture was of a magnitude never before undertaken by Corning. It would require the expenditure of sums on marketing and advertising activities increasing these costs relative to Corning's other products and reduce the gross margin on the CORNING WARE line. This he realized would be offset by the volume opportunity which could be obtained.

The cost and sales data were analyzed in respect to gross margin, payback, net profit, return on investment and compared with Corning's requirements. Although these figures were in total favorable, Waterman's ability to convince Top Management that the figures were reliable and operations could be effectively implemented, was critical in his presentation. On the basis of these figures and Waterman's dynamic sales effort, the company's commitment was established. An incremental plan of implementation was established with general fundings approved for each segment, conditioned on the successful completion of the previous increment. To obtain funds for the completion of each step of a segment, an appropriation request was required. This request was required to justify each capital expenditure on its own merits of profitability, return on investment, etc. Through approval of such an appropriation request, Waterman obtained the capital required to construct the mold sets and make the tank modifications necessary for a volume production run for a market test.

The market test, taking place in the New England area, obtained three objectives. It obtained further documentation of projected sales figures, established effective marketing approaches, and ironed out the major remaining problems of production operations.

The responsiveness of the New England market to CORNING WARE surpassed all expectations. Sales projections were evaluated upward and additional productive facilities contemplated.

Differing marketing approaches were tried in geographically distant New England areas to determine which would be most effective. One of the most successful promotional strategies proved to be CORNING WARE's identification as a space age material; nose cone cookware. This link with a highly reliable, government-backed application of the same PYROCERAM family (Radome) established the credibility of the claims Corning was making for its product. It further convinced the consumer this was a genuinely new material and not merely an off-shoot of things with which she was already familiar.

During the production run for the New England market test, production problems similar to those encountered in the sales test run occurred. The approach to their resolution was essentially the same. Additional process know-how and efficiencies were established during the run. This allowed for a more specific cost analysis to be determined.

On the basis of the increased confidence levels generated from this market test, Corning committed itself to full production of the CORNING WARE line. The increased levels of confidence were derived, analyzed and presented in the same manner as discussed after the Rochester sales test.

A national roll out began with the initial three piece line, area by area as productive efficiency increased. Concurrently, on the basis of the projections derived from the market test figures, the A Factory productive capacity was deemed insufficient. An appropriation request was approved for the construction of a new plant facility for the exclusive manufacture of CORNING WARE. Upon completion of this facility, in Martinsburg, West Virginia, operations were transferred to it. This allowed the national roll out to proceed at an increased pace and provided for the productive capacity anticipated as required when the line was broadened.

iv. Follow Up

From the original three piece line aimed at the top-of-the-range segment of the cookware market, CORNING WARE has become "the dominant factor in the total cookware market."[1] This has occurred through realization of facts previously unnoted which provided the impetus for skillful exploitation of the cookware market by product addition.

As CORNING WARE sales increased, feedback to the Consumer Products Development group occurred during their market monitoring. They were constantly confronted by statements praising "Those wonderful CORNING WARE casseroles." The significance of these statements was not immediately realized. However, after numerous repetitions of such statements it was discerned that CORNING WARE, which had been conceived of and promoted as a range top line, was being received by the consumer as a total

[1] Mr. John Marakus during interview.

cookware line. The consumer, due to the product's beauty and versatility, was willing to pay two and a half times the cost of PYREX oven ware to utilize CORNING WARE as an oven utensil. With this factor realized, it was consciously promoted and additional products developed around it. The line has expanded into beverage makers, casserole items, specialty items and electromatics in a wide variety of sizes to capitalize upon this concept.

Related PYROCERAM items have been developed largely from the stimulus provided by CORNING WARE's success. CENTURA tableware and THE COUNTER THAT COOKS are two such items.[1]

The development of the CORNING WARE story to present is one of an evolutionary nature. The market was initially unsatiable for products in the CORNING WARE line. As new product applications were offered the market, they were for the most part enthusiastically received. In 1965 the market stabilized due to three major influences: CORNING WARE was no longer a new product, TEFLON cookware was introduced, and style and color considerations were

[1]THE COUNTER THAT COOKS is a direct extension of the technology gained in the development of the CORNING WARE electromatic skillet.

becoming requirements for salability.

These influences resulted in an overstocking of distributors and some deep soul-searching in the Consumer Products Division. CORNING WARE's standard cornflower design had been exploited by making new CORNING WARE products out of PYROCERAM material. As the number of items which could be made was exhausted the standard style and design were not enough to stimulate sales further. Therefore, sophisticated marketing techniques were deemed appropriate to achieve continued sales increases. These techniques have resulted in dropping certain CORNING WARE items in an attempt to establish a tightly knit group of best selling items in the standard cornflower design. To this base, lines in differing shapes and colors have been added; avocado and butterscotch being the most recent. This action has resulted in renewed sales gains and appears promising to continue in the future.

The effects of CORNING WARE sales on divisional and corporate profits can only be estimated due to the unavailability of such figures.[1] It would be an

[1]These figures were requested, on an index basis, but not available due to policy considerations. An estimate, from personal experience and the impressions gained during interviews, indicates the Consumer Products Division to account for approximately 30% of Corning's sales or about $135 million. CORNING WARE's portion of these sales is approximately $40 or 35% of division sales. Comparing this figure to Table 3 indicates Corning to have 40% of the total cookware market.

understatement to say the effect has been significant. Prior to the introduction of CORNING WARE the Consumer Products Division had been one of the smaller and somewhat stagnant divisions within Corning. This division is now a major influence within the company and is acknowledged as the growth division of the company. Corning's earnings rose sharply after the introduction of CORNING WARE from \$17 million in 1958 to \$24 million in 1959. The exact portion which CORNING WARE contributed to this and subsequent profitability is uncertain. However, from the breadth of the product line established around CORNING WARE it must be assumed to be of a major nature.

A more concrete measure of the importance Corning has placed on the CORNING WARE development is the pattern of career development of those individuals most responsible for its successful innovation. The rise of these individuals within the corporate hierarchy must have been somewhat proportional to the success of CORNING WARE.

Individual	Position 1958	Position 1968
R. Lee Waterman	V.P. & General Mgr. Consumer Products Division	President of Corning Glass Works
Ray O. Voss	Supervisor of Consumer Product Development	Director of C.G.W. Product Development
George J. Bair	Manager Quality and Process Engineering	Director of C.G.W. Technical Staff Services
Don S. Stookey	Mgr. of Fundamental Chemical Research	Director of C.G.W. Fundamental Research

CHAPTER VI

EVALUATION AND ANALYSIS

The firm's goals and strategies, as determined by the model, define corporate objectives and decide the general scientific and technological areas in which it should concentrate. These areas of interest allow the firm's individual functional units to develop specific strategies accomplishing objectives consistent with overall corporate goals.

Corning's objective to pursue excellence in glass and its related technologies throughout the world, determines these areas to be of general interest as discussed in the model. Corning accomplishes its general objective by applying technology to new markets and through further penetration of established markets. This strategy requires Corning to maintain a large and expanding program of research and development to insure the possession of new technology for application. The internal generation of new technology for commercialization is coupled with a growth objective of 10 percent per annum in both sales and profits.

The CORNING WARE case demonstrates the method which the Consumer Products Division utilized to develop a specific strategy to accomplish corporate objectives. This strategy departed from the company's primary orientation as a supplier of original equipment manufacturers. Before examining this development in full it is necessary to return to return to the model to examine the corporate planning process and its effects on updating corporate goals and strategies.

The model defined corporate planning as the firm's conscious attempt to integrate forecasts from its organizational units with an appraisal of its external environment. This integration and subsequent analysis provides a projection enabling the firm to identify the technology required to insure present product lines and provide a basis for new products and applications consistent with corporate objectives.

Corning's planning activities have historically forced this process into divisional levels. A coordinating function is performed at the corporate level by deriving the format by which divisional managers are to plan. In conducting the planning function in this manner Corning has felt the individuals best qualified, the division managers, would be determining Corning's current and future role within a particular market.

When comparing Corning's objectives and planning function to the corporate climate existing prior to the CORNING WARE case the adequacy of Corning's methods for updating plans and objectives becomes questionable.

Corning's general corporate strategy had evolved to the application of Corning's glass technology to solve problems, or provide benefits for other manufacturers' consumer products. This does not imply Corning did not produce, or contemplate producing final products under its own name but rather the major portion of its business was with original equipment manufacturers. By acting predominantly as a supplier of original equipment manufacturers, Corning's division managers were not required to utilize extensive consumer research techniques, establish widespread distribution systems, or run the risk of producing products the market would reject. By working to specifications established by others, technology could be transferred from research and development activities without the degree of uncertainty, expense or exposure associated with consumer-oriented products. The division manager was therefore more likely to obtain the margins required of him to obtain Corning's growth and profit objectives.

There was nothing "wrong" with attempting to achieve corporate goals in this manner. However, as Corning exhausted applications of technology in its traditional markets, profits stabilized and corporate growth objectives were not accomplished. This indicated that Corning's planning function was required to develop supplementary methods, as the existing planning process was adequate only as long as significant technological application remained within established markets. In its history, Corning has not consistently identified the exhaustion of established markets, or when and what new markets should be sought.

President Decker's desire to bolster the company's consumer orientation was Corning's major effort to identify a wide range of markets, to assure areas of application for Corning's highly developed glass technology. Decker's realization, that continued emphasis on former businesses would limit growth potential, did not arise through the corporate planning process as it should have to be consistent with the model.

Since the CORNING WARE case, Corning has realized its deficiencies in the planning area and has attempted to include the considerations prescribed in the model within its corporate planning function. The Glass Top Conference Corning conducts is a periodic assessment of the company's future in the external world. Corporate Business Development is a continuing function further responsible for determining Corning's role in the environment which surrounds it. It has responsibility for identification of new markets and businesses to guarantee the continuation of Corning's growth and profit objectives. Planning within established markets is left to division managers and coordinated, in the manner previously described, by the Forward Planning Department of Corporate Business Development.

Corning's development of new businesses has created conditions requiring a revision of objectives in Corning's rate and method of growth. As Corning shifted toward forward integration, it initially sought market opportunities closely related to its traditional lines of business in which it had some degree of familiarity. With these markets developed, Corning pushed out into areas on the fringe of its traditional interests. In establishing businesses in fringe areas, Corning invests large sums to gain the familiarity required to successfully develop these markets. Such developments have required intensive market research activities, new production methods and differing systems of distribution, all resulting in additional costs burdening the corporate growth objectives.

If Corning must maintain a growth objective of 10 percent a year in both sales and profits, it must alter its philosophy on internally generated growth. This can be accomplished through acquisition of corporations familiar with the desired market to which Corning's technology can be effectively applied. Corning appears to be moving in this direction. It has formally recognized the possibility through establishment of an acquisitions department within Corporate business development, and has had a recent success in entering the electronics field by acquisition of The Signetics Corporation.

The preceding analysis underscores the importance of the interaction of the planning function and corporate objectives as proposed by the model. These activities effectively enlarge or restrict the scope of the areas in which a firm will innovate. If there is not a high degree of interaction between planning and objectives, the firm may drift into a position where its plans for objective accomplishment are unrealistic, or objectives inappropriate in view of current or anticipated developments.

The organizational environment advanced by the model as essential to the innovative firm was one of an organic nature. Within this organic structure the firm can further encourage responsiveness to change through its management attitudes and policy framework. The attitudes and policies which accomplish responsiveness are those encouraging flexibility and rewarding those individuals responsible for successful change.

Corning's current organizational environment surpasses the considerations proposed by the model. Corning's strategy, of technological application to accomplish its objectives, creates an atmosphere within the corporation establishing change as its essential need. Cornings' responsiveness to change reenforces, dependent upon the magnitude of, the current or anticipated developments required for corporate success. Additionally, Corning gives formal recognition to, and promotes the informal processes which occur within the organization. In informing individuals of the system's workings and the methods which achieve its most effective utilization, Corning allows individuals and groups to consciously work toward achieving effectiveness within the organization. The attempt to achieve effective operations is significant in obtaining their accomplishment.

The CORNING WARE case exemplifies the operation and importance of Corning's organizational environment. The degree of formal and informal interaction among the individuals and groups involved in the CORNING WARE development, their reliance upon and involvement in the activities of others, and recognition of the development's importance, promoted a responsiveness and sense of purpose to accomplish the CORNING WARE development in an eighteen month period. This rate of innovation indicates the effect the organizational environment can have on the time factor which is becoming increasingly important to achieve successful innovative activities.

Corning's policy of rewarding those responsible for successful innovative activities is observable from the career development of those individuals influential in the development of CORNING WARE. The rise of these individuals in the corporate hierarchy indicates the importance and desirability Corning places upon rewarding successful innovators.

Corning's creation of conditions to establish and maintain an effective organizational environment indicate an additional dimension should be emphasized in the model. Emphasis should be placed on the firm's ability to define and utilize the informal workings of its organization to facilitate the innovative process.

Communications were stressed in the model as a critical component of the innovative process. It was deemed essential that effective methods of communication exist to transfer the necessary technological information from external sources to those individuals who can apply it; and channel the information to those individuals who can combine the application with capital for its commercialization.

Corning's communication system utilizes formal methods including: period review meetings, semi-annual Technical Staff product reviews, monthly summaries of research and development activities, and divisional follow ups on R.F.T.'s. Supplementary to these are memos and informal communications which are significant methods for

Corning's innovative activities.

The CORNING WARE case demonstrates the process of communicating technological information in its transfer to commercialization. The case exemplifies the interaction of individuals and groups which occurs during innovative development at Corning.

Corning's communication of technological information, in addition to normal vertical channels, accomplishes wide horizontal communication creating a sense of technological awareness throughout the corporation. Corning's wide dissemination of technological information provides the basis for establishing the involvement of many diverse groups in innovative activities.

Corning's system of communications indicates the model should more heavily stress establishing the involvement of the firm's organizational units in the communication process.

The model of the firm determined external stimulation to be essential for effective and continued innovation. Key elements defined were: technological stimulation through research and development activities; customer and competitor stimulation provided by operating divisions, or organizational units charged with this responsibility.

Fundamental and applied research activities were proposed by the model to require: the awareness of technological developments within the firm's areas of interest; controls to allow evaluation of projects in relation to corporate objectives; flexibility to allow pursuit of individual projects by researchers; responsiveness to customer and competitor inputs; funding adequate to successfully carry on these activities.

Corning's central research and development activities have the responsibility to develop the technology required to establish new businesses and allow existing businesses to flourish. To assure awareness of its external environment, Corning's Technical Staffs Division has established a technical information center and carries on liaison activities similar to the library and search functions described by the model.

Corning believes its fundamental and applied researchers, being experts in their respective fields, are best able to propose projects in the company's interest. The researchers' activities are not undirected as their projects are subject to review after one week's exploratory investigation. The Director of Technical Staffs evaluates the project on a basis which is not overly formal but appraises the project's relevance to Corning's interests.

The CORNING WARE case shows the above process in operation by a description of Dr. Stookey's activities and the evaluation of his projects during the research stage of the development of CORNING WARE.

At Corning the influx of customer and competitor stimulation occurs through divisional marketing activities and is communicated to the Technical Staffs by formulation of a written Request For Technical Assistance (R.F.T.). An R.F.T. contains information identifying market opportunity, expected profitability, and the technology required. This allows the Director of Technical Staffs to pursue research in areas which potential profitability has been defined.

Corning's fundamental and applied research activities conform generally to the conditions prescribed by the model. Corning's activities in these areas, however, are more informal than indicated in the model. This informality appears to result from Corning's general organizational philosophy and possession of competent researchers. The informal method has worked previously for Corning, whether it continues to be effective is largely dependent upon the ability to maintain its organizational philosophy and acquire competent researchers while growing at its current rate.

Effective development activities, in addition to the requirements for successful research, were required by the model to provide the following conditions:

a) Provide an initial screening function to select appropriate projects for development.

b) Provide the commercial information necessary for adequate design and development of the product.

c) Establish a system for planning, control and reevaluation of the project's development.

Corning's basis for initiating development activities or transferring research into development rests upon the R.F.T. mentioned previously. Prior to entering product development, market research is conducted clearly defining market opportunity, competition, qualities required of the product, any divisional restrictions for production, and the expected market share the product will obtain. On this information the Director of Technical Staffs evaluates the acceptability of the proposal. His considerations, listed in the text, are highly formal in comparison to the standards for initiation of fundamental and applied research.

Written R.F.T.'s did not formally exist during the CORNING WARE development. The R.F.T. procedure is a direct outgrowth of Corning's experience following the success of CORNING WARE.

At the time of the CORNING WARE case technical assistance was granted divisions by the Director of Technical Staffs on the basis of informal communication with the division manager. As Corning's philosophy shifted to a higher degree of consumer orientation and CORNING WARE proved successful, the Technical Staffs Division was flooded with requests for technical assistance. To control research and development activities, assuring attention to areas with the largest potential profitability and allow for the establishment of priorities, the written R.F.T. procedure was instituted in 1964.

The evaluation of R.F.T.'s by the Director of Technical Staffs performs the screening function prescribed by the model. While not as complex as the model proposed by Ansoff it accomplishes a similar function. It allows the ranking of completing projects, places projects in relation to corporate goals, and provides a mechanism for anticipating costs and problems during development.

Corning provides commercial information for product definition and process specification through divisional marketing groups, working in conjunction with Technical Staffs development groups. Marketing departments at the division level will derive possible product designs on the basis of initial market information. Technical Staffs' development groups concern themselves with establishing general material and process specifications for the product's production. The product designs are appraised in opinion and attitude tests and a final design fixed. With the design finalized the specific product and process specifications are determined by the Technical Staffs. A prototype is then constructed and further attitude and service tests conducted. If revisions are indicated as necessary, they are made enabling the product to be finalized prior to sales testing.

The sales test requires a production run of the product, an evaluation of the process, and analysis of test results. These results document sales projections and establish general production costs. The documented sales and cost information provides additional data for an appropriation request to obtain capital funds for full production of the product. Prior to Corning's total commitment to the product line, a market test is conducted to further establish the acceptability of the product. If the market forecasts are borne out during the market test and no unresolvable production or process problems have arisen, the product will be established as a product line and full production begun.

Corning's plan for, and control of, product development is initiated upon approval of the R.F.T. Corning utilizes the project manager approach (for major developments) to plan and control development activities <u>and</u> transfer development into operations. The project manager has responsibility for, and authority to develop the product into a going business. It is usual for him to report to the division manager.

Corning's control procedures are of an incremental nature. If all indications within a segment of development are favorable the project will proceed into the next phase. The phases of development which a project must pass through are:

a) General material specification and design.

b) Design finalization and specific product and process specification.

c) Prototype creation, testing and reevaluation.

d) Production for sales test.

e) Volume production run for market test.

f) Commitment to product as a line of business.

The most critical phase occurs prior to the volume production run for market testing. This is the stage at which capital funds must be appropriated to continue development.

The CORNING WARE case did not utilize the current project manager approach. The CORNING WARE development used a coordinator to integrate the activities of the various groups involved. The coordinator in effect acted as an aid to the division manager. He had no decision making authority in the product's development, as this responsibility was left in the hands of Mr. R. Lee Waterman.

Corning's adoption of the project manager approach is an attempt at coordination for implementation similar to new venture management indicated in the model. It creates a product oriented group with an entrepreneurial spirit which minimizes resistance throughout development and eases transfer to operations.

The preparation of a detailed technical-economic analysis was advanced by the model as the basis for obtaining capital funds. Corning utilizes an appropriation request for this purpose. Approval of an appropriation request requires justification of each capital expenditure on its own merits, in relation to Corning's corporate requirements.

Corning's use of the appropriation request performs a function similar to that prescribed by the model's technical-economic analysis. It allows ranking of projects for selection of those most profitable, and provides for reevaluation of the project on a quantitative basis as additional funding is required.

Corning's development activities have undergone two major revisions since the CORNING WARE case. The adoption of written R.F.T.'s and the project manager approach align Corning's activities closer to those prescribed by the model. These have been additional revisions, in the specific conduct of development activities, which are of an evolutionary and minor nature.

CORNING WARE's development was Corning's initial attempt at consumer commercialization of such magnitude. The conduct of activities in the CORNING WARE innovation provided a base from which subsequent development activities took direction. As Corning undertook more commercializations of this nature it broadened its base of experience. With increased familiarization of the development process Corning has become more sophisticated in its development activities. Corning's evolvement to its current development process gives additional credence to the conditions prescribed by the model.

The model, for transfer of development activities to operations, determined transfer to operating divisions, a new product division, or a separate business venture as the most common instruments. To be successful the transfer required planning and control throughout the cycle. Methods advanced as appropriate for this purpose were P.E.R.T. networks and budget reviews.

Corning utilizes operating divisions or its new business division to effect transferto operations. Transfer is a misnomer in Corning's case, as Corning's development process involves those ultimately responsible for operations at the initialization of development activities. As previously discussed, the project manager is responsible for implementation of operations. He will assemble the functional specialists required to effect transfer, usually the individuals involved in the product's development, and establish an organization to carry on normal business activities. The staff specialists and production personnel work closely together, usually on a one to one basis, during initial production runs. As the production process stabilizes, these specialists are reoriented to other activities. The remaining group may be augmented to effectively continue business as the product's sales dictate.

If the product is in Corning's existing lines of business, development to operations will be conducted by an operating division. Upon stabilization of this business it is usual for that business to become a department of the division, with the project manager at its head.

CORNING WARE was not developed to operations through a projcet manager approach. However, if Waterman is considered a project manager, the CORNING WARE case demonstrates the manner in which a project manager of an operating division conducts product development.

Products in the fringe areas of Corning's interests are developed and put into operations by Corning's New Business Division. This division has an entrepreneurial flavor in the sense of new venture management as prescribed by the model. The stabilization of production may provide the basis for the establishment of a new division to further develop this market.

Control of development and transfer to operations is achieved at Corning through project review meetings, budget reviews, and P.E.R.T. networks, in addition to normal superior subordinate controls. Control is based on the incremental method discussed earlier.

Corning's procedures for transfering development activities into production operations indicate the desirability of not exclusively considering this process a dichotomy. Corning's activities indicate the model should accentuate involving those responsible for final operations as early as possible in the development process. Their early involvement facilitates the transfer to operations.

This chapter's analysis generally confirms the model of the innovative firm. Corning's philosophies and successful conduct of activities indicate the necessity of accentuating certain of the model's dimensions to achieve a more effective description of the conditions required for successful innovation within the firm.

The evaluation of Corning's performance as an innovator indicates the importance of the need for technological change in this corporation. The need for technological change is the focal point around which Corning is organized to accomplish its objectives. Its structure, philosophy and strategies arise from Corning's belief in support and exploitation of a productive research and development capability. This allows Corning to assure itself of potentially profitable products which continue to provide means for achievement of Corning's growth and profit objectives.

Corning's planning function for updating its goals and strategies, in the light of current and anticipated conditions, is a weak and historically inconsistent function within the corporation. Corning's adherence to accomplishing internally generated growth in unfamiliar markets has resulted in burdensome costs of market development, restraining consistent achievement of growth objectives. Corning has recently moved to correct these deficiencies but still maintains strategies which hinder its corporate growth objectives.

Corning's organizational environment, system of communications, Technical Staffs Division, development activities, and methods for transfer to operations are effective in achieving innovation. The ability to obtain, disseminate, and commercialize technological information is Corning's strongest point.

This strength, if properly exploited, should allow attainment of Corning's growth objectives in the near future. To properly exploit this strength the corporate

APPENDICES

planning process must be improved, along the lines suggested by the model, and strategy shifted to allow acquisitions within unfamiliar markets. By acquiring corporations with market knowledge, Corning can establish a means for application of its technology without the high market development costs presently being incurred.

Corning's weakness in updating its goals and strategies has as its ultimate result the inability to fully capitalize upon the potential profitability its innovative strength provides.

APPENDIX I

ORGANIZATION CHART: THE CORNING GLASS WORKS

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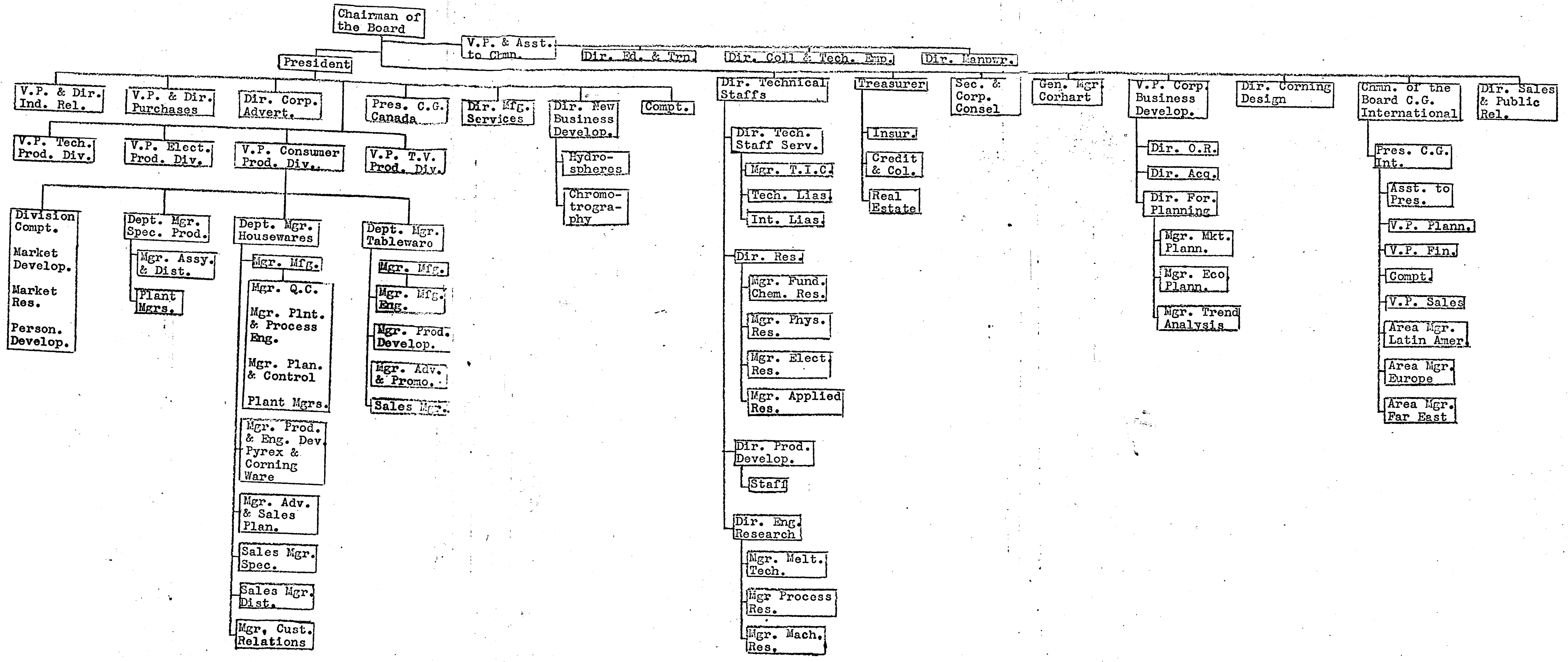

Chairman of the Board
V.P. & Asst. to Chmn.
Dir. Ed. & Trn.
Dir. Coll & Tech. Emp.
Dir. Manpwr.
President
V.P. & Dir. Ind. Rel.
V.P. & Dir. Purchases
Dir. Corp. Advert.
Pres. C.G. Canada
Dir. Mfg. Services
Dir. New Business Develop.
Hydro-spheres
Chromo-trogra-phy
Compt.
V.P. Tech. Prod. Div.
V.P. Elect. Prod. Div.
V.P. Consumer Prod. Div.
V.P. T.V. Prod. Div.
Division Compt.
Market Develop.
Market Res.
Person. Develop.
Dept. Mgr. Spec. Prod.
Mgr. Assy. & Dist.
Plant Mgrs.
Dept. Mgr. Housewares
Mgr. Mfg.
Mgr. Q.C.
Mgr. Plnt. & Process Eng.
Mgr. Plan. & Control
Plant Mgrs.
Mgr. Prod. & Eng. Dev. Pyrex & Corning Ware
Mgr. Adv. & Sales Plan.
Sales Mgr. Spec.
Sales Mgr. Dist.
Mgr. Cust. Relations
Dept. Mgr. Tablewaro
Mgr. Mfg.
Mgr. Mfg. Eng.
Mgr. Prod. Develop.
Mgr. Adv. & Promo.
Sales Mgr.
Dir. Technical Staffs
Dir. Tech. Staff Serv.
Mgr. T.I.C.
Tech. Lias.
Int. Lias.
Dir. Res.
Mgr. Fund. Chem. Res.
Mgr. Phys. Res.
Mgr. Elect. Res.
Mgr. Applied Res.
Dir. Prod. Develop.
Staff
Dir. Eng. Research
Mgr. Melt. Tech.
Mgr Process Res.
Mgr. Mach. Res.
Treasurer
Insur.
Credit & Col.
Real Estate
Sec. & Corp. Consel
Gen. Mgr. Corhart
V.P. Corp. Business Develop.
Dir. O.R.
Dir. Acq.
Dir. For. Planning
Mgr. Mkt. Plann.
Mgr. Eco Plann.
Mgr. Trend Analysis
Dir. Corning Design
Chmn. of the Board C.G. International
Pres. C.G. Int.
Asst. to Pres.
V.P. Plann.
V.P. Fin.
Compt.
V.P. Sales
Area Mgr. Latin Amer.
Area Mgr. Europe
Area Mgr. Far East
Dir. Sales & Public Rel.

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APPENDIX II

TABLES

TABLE 1

GENERAL STATISTICS FOR PRESSED AND BLOWN GLASS INDUSTRY
(EXCLUDING CONTAINERS)
1958 THROUGH 1965

Year	All Employees		Production Workers			Value Added by Mfg	Cost of Materials ($1000)	Value of Shipments ($1000)	Capital Expenditure New ($1000)	End of Year Inventories ($1000)
	Total (Numbers)	Payroll ($1000)	Total (Numbers)	Man Hours ($1000)	Wages ($1000)					
1965	39,623	230,943	34,550	68,238	189,941	570,180	223,866	788,995	45,151	104,995
1964	38,386	216,473	32,737	65,886	175,749	529,839	210,983	730,970	38,826	101,553
1963	37,999	207,292	33,857	64,855	167,921	472,212	167,473	630,945	22,664	
1962	38,137	199,651	33,117	64,718	161,151	448,081	174,544	619,471	24,420	
1961	37,443	190,388	32,380	62,730	153,794	425,338	163,938	584,751	27,554	
1960	37,078	181,817	34,252	67,545	162,064	408,843	173,282	568,917	41,816	
1959	37,972	184,001	33,361	65,771	152,257	398,648	151,789	547,473	33,827	
1958	35,358	161,296	30,473	58,974	131,851	312,342	128,892	445,361	19,387	

Source: Annual Survey of Manufacturers 1964-1965, U.S. Department of Commerce, Bureau of the Census, U.S. Government Printing Office, Washington, D.C., p. 73; Annual Survey of Manufacturers 1962, U.S. Department of Commerce, Bureau of the Census, U.S. Government Printing Office, Washington, D.C., p. 287.

TABLE 2

VALUE OF SHIPMENTS OF PRODUCT CLASSES IN THE PRESSED AND BLOWN GLASSWARE INDUSTRY (EXCLUDING CONTAINERS) 1958 THROUGH 1965

Year	Pressed and Blown Glass Products Total	Table, Kitchen, Art and Novelty Glassware	Lighting and Electric Glassware	Glass Fibers	Other Pressed and Blown Glassware	Pressed and Blown Glassware NEC, NSK
1965	779,431	257,638	270,878	128,273	121,763	(879)
1964	715,083	257,989	243,216	108,535	105,156	(187)
1963	610,030	216,226	210,261	91,123	92,018	402
1962	592,891	195,585	198,222	106,180	109,138	
1961	572,694	193,440	171,801	89,895	117,558	
1960	566,391	188,534	169,894	87,609	120,354	
1959	545,450	174,456	171,696	84,217	115,081	
1958	447,997	149,006	143,286	59,670	96,035	

Source: 1963 Census of Manufacturers II, Industry Statistics, Part 2, U.S. Department of Commerce, Bureau of the Census, U.S. Government Printing Office, Washington, D.C., p. 32A-6, and Annual Survey of Manufacturers 1964-1965, U.S. Department of Commerce, Bureau of the Census, U.S. Government Printing Office, Washington, D.C., p. 73.

TABLE 3

PRODUCTION AND SHIPMENTS OF TABLE, KITCHEN, ART AND NOVELTY GLASSWARE
1964 and 1965

Item	Unit of Measure	1965				1964			
		Total Shipments		Shipments by Establishments Mfg. Glassware Primarily From Glass Produced in Same Establishment		Total Shipments		Shipments by Establishments Mfg. Glassware Primarily From Glass Produced in Same Establishment	
		Quantity	Value ($1,000)	Quantity	Value ($1,000)	Quantity	Value ($1,000)	Quantity	Value ($1,000)
Total: Table, kitchen, art and novelty glassware		X	D	X	250,126	X	D	X	256,213
Machine-made: tableware, cookware, ovenware, kitchenware	1,000 pieces	410,485	107,566	391,040	103,543	414,468	125,412	393,988	121,592
Hand-made tableware	1,000 pieces	8,631	8,697	D	D	8,528	9,609	D	D

Source: Annual Survey of Manufacturers 1964-1965, U.S. Department of Commerce, Bureau of the Census, U.S. Government Printing Office, Washington, D.C., p. 472.

TABLE 4

PERFORMANCE OF CORNING GLASS WORKS
1958 THROUGH 1967

Year	Net Sales (Millions)	Net Sales (Millions)
1967	435.33	50.02
1966	444.14	54.17
1965	340.47	38.69
1964	327.61	35.02
1963	289.22	31.57
1962	262.20	28.10
1961	229.57	25.92
1960	214.89	22.06
1959	201.37	24.34
1958	159.14	17.16

Source: Corning Glass Works Annual Reports.

TABLE 5

THE CORNING GLASS WORKS' RESEARCH BUDGET AS A PERCENTAGE OF NET SALES 1952 THROUGH 1963

Year	Net Sales (Millions)	Research Budget (Millions)	Research Budget Net Sales (Percent)
1963	289.22	15.4	5.3
1962	262.20	NA	NA
1961	229.57	10.7	4.7
1960	214.87	NA	NA
1959	201.37	8.1	4.0
1958	159.14	6.9	4.3
1957	159.0	5.63	3.5
1956	163.0	4.79	3.0
1955	158.0	5.32	3.3
1954	148.0	4.49	3.0
1953	149.0	5.22	3.5
1952	126.0	3.29	2.6

Source: Corning Glass Works Annual Reports.

APPENDIX III

PRODUCT AND MARKET DESCRIPTION: CORNING WARE

CORNING WARE:
Product and Market Description

I Material: a composition of Pyroceram Brand glass ceramics

II Qualities:
- a) expands and shrinks less under sudden temperature changes than any known ceramic
- b) resists corrosion by powerful acids even at extreme heats
- c) stronger (in ratio to its weight) than stainless steel
- d) has half the tensile strength of steel
- e) holds a weight of 40,000 lbs./sq. in. which is as much as aluminum
- f) light as aluminum
- g) as strong as good aluminum alloys
- h) harder than steel of flint
- i) softening temperature almost up to melting point of iron; above melting point of gold or copper; far above useful service temperature of steel

III Unique Consumer Benefits:
- a) can be cooked in and removed directly from heat and placed in freezer and vice versa; can be utilized to serve food either from heat or freezer
- b) provides aesthetic beauty for cooking, storing and serving of foods.

IV Design (see enclosed ad on page 123)
- a) "squarical" shape in cornflower design with clear cover and detachable plastic handle
- b) round shape in various solid colors with opaque cover and detachable plastic handle
- c) or design as prescribed by product's function

V Depth of line:
- a) Beverage makers, saucepans, skillets, casseroles, specialty items and electromatics in a wide variety of sizes

VI Market:

a) The Cookwares Market comprised of:
   1) Tableware - items from which food is eaten or served
   2) Ovenware and Kitchen ware - items used to cook over direct heat; items used in the preparation and storage of foods: items in which food is cooked in the oven

b) Types of items - saucepans, skillets, coffee makers, casseroles, baking pans, refrigerator dishes

c) Competition
   1) Any materials which are sold for use in the above functions
   2) Tableware primarily china, glassware and crockery
   3) Ovenware and Kitchen Ware, primarily metal and glass items

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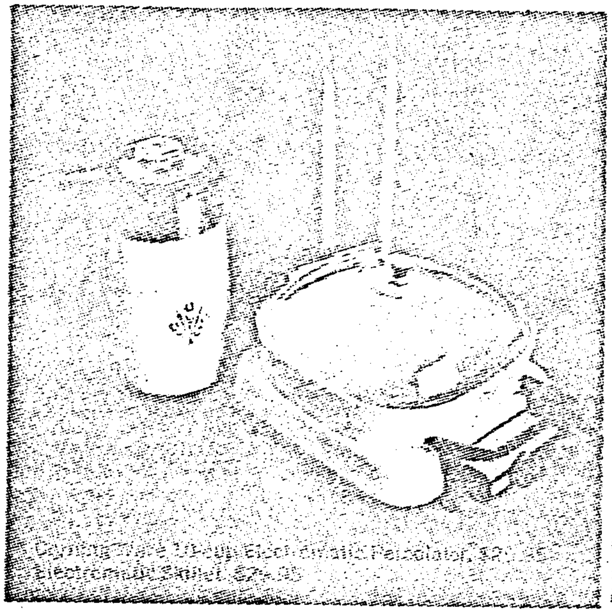
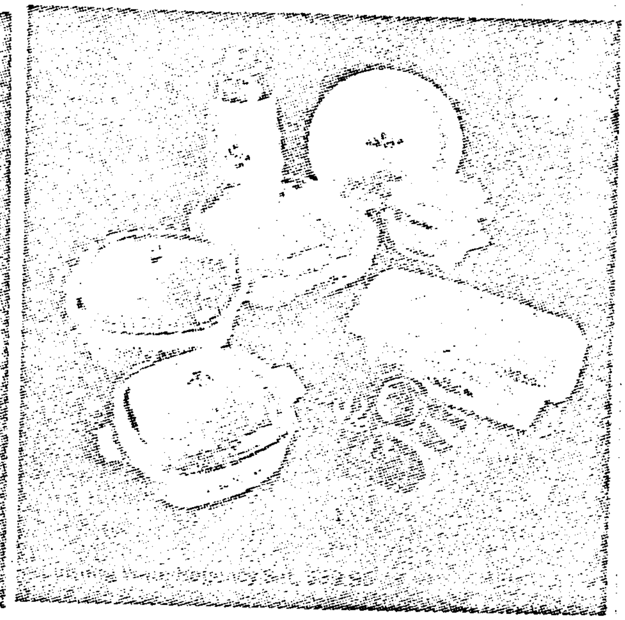
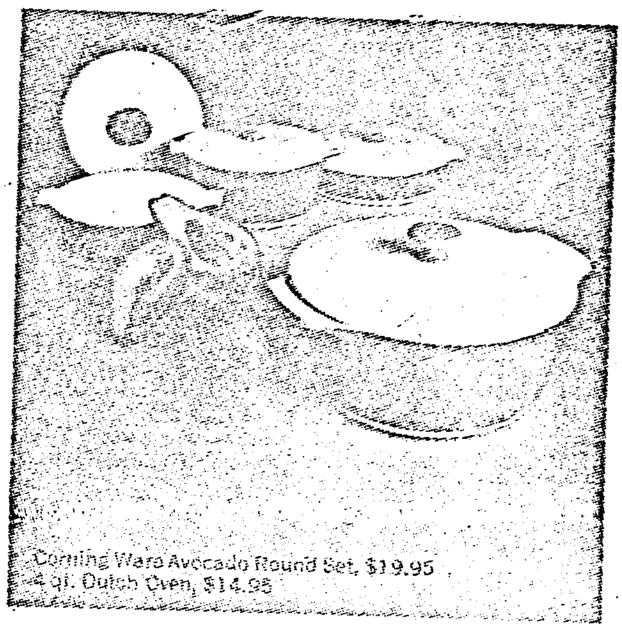


Corning Ware 10-cup Electromatic Percolator, $[illegible]
Electromatic Skillet, $[illegible]

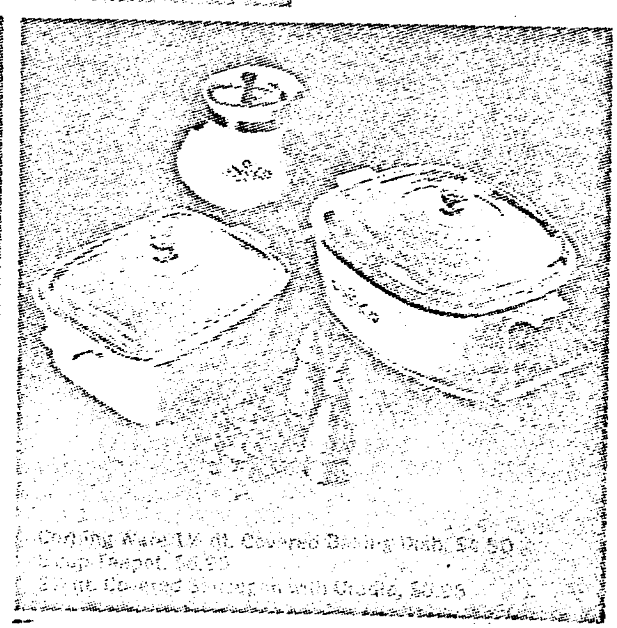


Corning Ware [illegible] Set, $[illegible]



Corning Ware Avocado Round Set, $19.95
4 qt. Dutch Oven, $14.95

Corning Ware [illegible] Set, $24.99



Corning Ware 1½ qt. Covered Baking Dish, $5.50
[illegible] Teapot, $[illegible]
2 qt. Covered [illegible] with Cradle, $[illegible]

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APPENDIX IV

INTERVIEW QUESTIONNAIRE

Questionnaire

I Background

A What is your title within the company and can you give us a brief description of your function.

B Can you give us some idea of your background in terms of education, previous experience, and the amount of time you have been with the company.

C What was your function during the development of Corning Ware. Can you describe your areas of responsibility.

II General Operational Environment

A Goals and Strategy

1 What are the objectives of C.G.W. as a firm.

2 What policies does C.G.W. pursue to insure accomplishment of these objectives.

3 What importance does C.G.W. place on technological innovation and how is it incorporated in its objectives and policies.

B Climate for Work

1 What is the organizational structure of C.G.W.

2 What is the philosophy behind this organizational structure.

3 Is the above consistent with the objectives and policies of C.G.W.

4 What is the role of the individual within this structure.

5 Do individuals within the organization clearly understand the limits or flexibilities of their function; the penalties and rewards involved.

6 What controls exist to insure the individual's compliance with company objectives within this organizational structure. What positive motivations other

than financial are encouraged through this organizational structure.

7 Are there recognized informal structures which serve to facilitate accomplishment of C.G.W. objectives. What are they and how do they differ from the formal channels.

III The Innovative Process

A Planning

1 Describe the forward planning process within C.G.W.

2 How is it structured to accomplish the over-all objectives of C.G.W.

3 What are the components of the planning process. What are the significant factors of consideration in these components.

4 What is the influence of technological innovation on and how is it incorporated into the planning process.

5 From where is information on technological innovation obtained and by what channels does it flow into the planning process.

6 What types of forecasting does C.G. W. concern itself with and how are these forecasts incorporated in the planning process. (Environmental, Sociological, Competitive, etc.)

7 What methods of forecasting are utilized in the planning process. (Trend extrapolation, Uncertainty measures, Delphi method, etc.)

B Research and Development

1 What are the objectives of these functions in C.G.W. Define each and indicate a rough estimate of the amount of funds spent on each.

2 What policies exist to insure accomplishment of these objectives.

3 How are R&D objectives and organization meshed with over-all C.G.W. objectives and organization.

4 What are the major sources of technological information for C.G.W. (Internal, External)

5 Is there one central storage center for technological information in C.G.W. If one center does not exist, where are the established points of storage for technological information. Does any coordination exist among these points.

6 Is technological information which may be of significance disseminated from storage to possible utilization points on a planned basis. If so, what route does it take; what are the qualifications of the individuals performing this function.

7 What are the routes of access to technological information. What are the requirements to obtain this information.

8 What is the basis for determining the direction of R&D efforts. What are the significant factors of consideration.

9 Does there exist within C.G.W. a definite function responsible for recognizing and appraising technological innovation. From what sources does it draw its information and what are the factors it considers.

10 Is C.G.W. structured so that it actually identifies technological concepts of importance.

11 How successful has C.G.W. been in utilizing information dissemination and transfer in new product identification or competitors actions.

C Decision Making

1 At what point is an idea, innovation or a set of proposed specifications first subject to a process of checks within C.G.W. (Appropriation request, additional funding or manpower request, approval to work on project)

2 What are the sequential steps an innovation will follow assuming it continues to production. What are the specific decision points at which it may be continued or dropped.

3 What are the factors of considerations at the decision points identified above. When are the detailed financial, marketing and production evaluations brought to bear. Some typical considerations are listed:

- a R&D Aspects
  - 1 research investment
  - 2 development investment
  - 3 research know how
  - 4 patent status
- b Financial Aspects
  - 1 rate of return
  - 2 est. annual sales
  - 3 time to reach est. sales volume
  - 4 net fixed capital outlay
  - 5 annual earnings
  - 6 total capital investment
- c Marketing and Product Aspects
  - 1 similarity to present product lines
  - 2 effect on present product lines
  - 3 marketability to present customers
  - 4 number of present customers
  - 5 suitability of present sales force
  - 6 market stability
  - 7 market trends
  - 8 service requirements
  - 9 promotional requirements
  - 10 market development requirements
  - 11 product competition
  - 12 product advantage
  - 13 product life cycle
  - 14 cyclical or seasonal demand
- d Production and Engineering requirements
  - 1 size of operation
  - 2 raw materials

3 equipment
4 process familiarity

4 What stage is most crucial in the evaluation process.

5 What factors are given the most significant considerations; are certain factors more significant at diferant stages.

6 Are technological considerations brought to bear on these factors of consideration. How and by whom.

7 As a project is brought into consideration and is in the process of development is a technological update used in evaluation (Improvements in existing technology, competitors actions, new technological developments)

8 Are negative factors given as much consideration as positive. What weight is given to what will happen if we do not.

9 Does a point of no return exist after which abandonment of a project is not considered, feasible or possible.

10 Is C.G.W. consistent in its methods of evaluation.

11 Who is finally responsible for the decision to continue or abandon a project at each decision point.

12 What is the rate of introduction of new products, processes and materials in recent years. Has it been accelerating, constant or regressive.

13 Have any changes been made to adapt to that rate.

14 What has happened to dropped projects. Have they been reevaluated; have competitors capitalized on them.

D Coordination

1 Who is responsible for the coordination of the different facets of the innovative project at the various stages of its progress. What are their objectives; their methods.

2 Do these groups change as the project progresses from inception to production. Are these changes partially complete or complementary.

3 How do these groups utilize stored technological information in their coordinated activities.

IV Corning Ware Case

A General

1 Can you by a flow chart presentation identify the chronological sequence of events from the discovery of a glass ceramic to the production of Corning Ware.

2 Within this framework can you chart the pattern of sequential decision making which took place and identify the factors of consideration at each decision point.

3 Having accomplished 1 & 2 can you identify the new increments of knowledge which were required to develop this discovery from inception to production.

4 Can you list the inputs which an individual or group utilized to achieve the desired increments of knowledge.

B Specific

1 What was the state and direction of Glass technology prior to the discovery of Glassceramics. (internal and external)

2 What means would you use to assess this; internal reports, informal communication, scientific publications.

3 Had the properties of a glass ceramic been considered R&D planning, forward planning, the scientific community. If so, why was this area not explored earlier.

4 What initial significance was given this discovery. By whom and on what basis.

5 What steps did Stookey take to explore this discovery. Where did he get inputs for the direction of his development. His own experience, help from co-workers, scientific community.

6 When was this discovery first reported to a superior. What were the results of this discussion; by Stookey and by the superior.

7 Was the resulting development at this time of a general or specific nature. What additional resources were committed at this time.

8 What sources of information were brought to bear and how did they flow into the development process.

9 When was research shifted from general to specific and what factors dictated this shift. How far developed was glass ceramic composition at this time.

10 What was the process of development of glass ceramics with specific product development. What activities were being carried on concurrently at this time.

11 What new increments of knowledge were required for the development of Raydomes and Corning Ware. What was their source and how were they achieved.

12 As the above were developed how was the knowledge gained transferred and coordinated for use in all glass ceramics. Was there a carry over between Raydomes and Corning Ware.

13 What were the cost of these new increments of knowledge and who bore them. Did the development of Raydomes perform research which would have had to be undertaken for the development of Corning Ware.

14 If Raydomes had not been needed by the Navy would Corning Ware have been developed as quickly.

15 At what point was a detailed market and financial analysis made. What effect did this have on the development process.

16 What stage of development was most critical in this development process.

17 What factors are given most significance in the evaluation of Corning Ware. Were some factors more significant at different stages.

c Follow Up

1 What effect has the development of Corning Ware had on the profitability of C.G.W., The Consumer Products Division. Has this conformed to the predicted profitability.

2 Have the projected market analysis been borne out. If not what factors have changed.

3 Was C.G.W. aware of the potential threat of Teflon. What effect has Teflon had on Corning Ware Sales.

4 What improvements are currently being worked on with respect to Corning Ware.

5 What is the future potential of Corning Ware. How is this analysis different from the original.

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APPENDIX V

INTERVIEWEES

INTERVIEWEES

Mr. Clark Crawford, General Manager, Industrial Products, November 22, 1968.

Mr. R. Lee Waterman, President, Corning Glass Works, November 22, 1968.

Mr. John Fiske, Director of Forward Planning, November 22, 1968.

Dr. George Bair, Director, Technical Staff Services, November 25, 1968.

Mr. Ray Voss, Director, Product Development, November 25, 1968.

Mr. John Marakus, Manager Marketing: Pyrex, Corning and Centura Ware, December 4, 1968.

Dr. Michael Beer, Manager, Organizational Research, November 25, 1968.

Mr. George Southworth, Manager, Product Planning, December 6, 1968.

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